Biotechnology and Development: Trends and Issues

Report

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Preface

In compliance with the Terms of Reference (see Appendix A) the Report focuses on biotechnology and development. In order to properly assess IDRC and its position on biotechnology, Section 1 locates biotechnology in the appropriate historical, science and technology, and developmental context. Section 2 discusses general and divisional developments at IDRC with regards to biotechnology and development. Canadian federal government policy developments in the area of biotechnology are covered in Section 3. Sections 4 provides a summary of policy developments and research initiative of donor agencies and international institutional initiative related to biotechnology that address the issues relevant to the developing countries. Finally, Section 5 raises several obvious short-term and more fundamental longer-term issues arising out of the nature of biotechnology, its potential, and trends in biotechnology research.

I like to acknowledge and express my thanks for the sincere and forthcoming support, assistance, cooperation and advice extended by IDRC management, officers and staff at all levels in the preparation of this Report.

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1. BIOTECHNOLOGY[1]

1.1. Introduction

Biotechnology is frequently described as part of the third industrial revolution together with micro-electronics. The revolutionary character of biotechnology is the fact that many of its varied applications are concerned with basic human needs. The impact of biotechnology is likely to be felt in many sectors, in agriculture and fisheries, human health care, environmental protection, energy, mining and industry.

Biotechnology holds great promise for humankind: it could put an end to famine; it could provide answers to diseases such as malaria, hepatitis-B and AIDS; it could solve problems of waste disposal; and it could help in the fight against deforestation and high energy costs. In particular, biotechnology could help to solve problems in developing countries.

Modern biotechnological research generally requires highly trained specialist researchers and large capital investments but, the application of biotechnology is often uncomplicated and non-capital intensive. Further, biotechnology applications do not usually require much energy. Use of these techniques is often highly flexible, and they can therefore be readily adapted to the specific conditions prevailing in developing countries.

Although biotechnology offers many new opportunities for developing countries, especially in the long term, its application also entails disadvantages. Several developments in the field of biotechnology can have predominantly negative socio-economic consequences for developing countries (e.g. substitution of raw materials, industrialization of agriculture and technology privatization). Biotechnology can also have negative consequences for humankind and environment, and in the case of the developing countries, these problems may be compounded by their economic weakness and limited legislation.

It will be difficult for developing countries to make optimum use of the potential offered by biotechnology. Due to their economic underdevelopment, backward industrial structure, lack of research capacity and deficient infrastructure developing countries will require more time before they can use biotechnology on their own. The use of biotechnology by these countries is largely dependent on the present and future balance of power in the field of biotechnology. There is a high risk of developing countries becoming even more dependent on the industrialized world. Hence it is extremely important that developing countries are given access to biotechnology, so that they can decide for themselves whether and how to make use of it. Development assistance and cooperation can play an important role in this regard.

While biotechnology is still at a very early stage of development and diffusion it raises numerous extremely important questions and issues: What is biotechnology? In which economic sectors is it likely to produce major impacts? What is the stage of development of biotechnology? Why and how is it so relevant for developing countries? What are the conditions that developing countries must fulfill to benefit from biotechnological development and application? What is the international setting in which these developments should be analysed? What are the international dimensions that condition its development and application in developing countries? What are the economic, social and political implications of biotechnological development, transfer and application?

1.2. Definition

Several definitions of biotechnology have been provided in recent years by different institutions and experts. This proliferation of definitions is partially the consequence of the multidisciplinary character of biotechnology (molecular genetics, biochemistry, microbiology and process technology) which reflects the difficulties encountered in establishing its boundaries. It is also a reflection of the diversity of its scope, including agriculture and fisheries, human health care, environmental protection, energy, mining and industry. Accordingly, one or another definition is adopted in accordance with particular interest regarding the purpose of biotechnology development and applications.

Biotechnology alternatively has been defined as;

- the integrated use of biochemistry, microbiology and technical sciences with the aim of arriving at the technological and industrial applications with the aid of micro-organisms, parts of micro-organisms or cells and tissues of higher organisms (European Federation of Biotechnology).[2]
- any technique that uses living organisms, or parts of organisms, to make or modify products, to improve plants or animals, or to develop micro-organisms for specific uses (European Community and Office of Technology Assessment of the US Congress).[3]
- the application of scientific and engineering principles to the process of materials by biological agents to provide goods and services (Organization for Economic Cooperation and Development, OECD). (This definition has been adopted by some of the European countries.)[4]
- the integrated use of molecular genetics, biochemistry, microbiology and process technology with the aim of supplying goods and services, specifically using micro-organisms, parts of micro-organisms, or cells and tissue or higher organisms (Director-General for International Cooperation, the Netherlands).[5]

- the application of science engineering to the direct or indirect use of living organisms or parts of organisms or products of organisms in their natural or modified forms, for the production of goods or the provision of services (MOSST).[6]

These definitions have one common aspect: they refer to the use of micro-organisms and biological agents. But, each of them reflect different purposes, or interests and strategies. The emphasise however is on the industrial character or relevance of biotechnology. Biotechnology tends to be defined as the industrial exploitation of biological systems or processes.

1.3. Traditional vs. New Biotechnology

Biotechnology in itself is nothing new. It has been used for thousands of years in the manufacture of food and beverages such as bread, beer, wine, cheese, soya sauce, and temphe. For centuries use has been made of the properties of micro-organisms, but without understanding them. The term "biotechnology" dates from the time when biological processes came to be understood and used consciously.

Briefly, the evolution of biotechnology can be divided into at least four periods. The pre-Pasteur period and the empirical practice of selection of animal and plant breeders and fermentation for food preservation. This era was characterised by the artisanal application of empirical understanding resulting from experience alone. It was practical understanding without theory or scientific base, technology without science.

The second period was initiated with Pasteur. Micro-organisms were identified as the cause of fermentation, followed by the discovery of the capacity of enzymes to convert sugar into alcohol. This development gave impulse to fermentation technique in the food industry. The third period was characterised by important technological developments which reduced the impetus of biotechnology development in certain areas while giving rise to development in other areas.

The last period started with the discovery of the double helix structure of DNA in 1953, the first experiments on genetic engineering in 1973, and the discovery of the hybridoma technique for the making of monoclonal antibodies in the first half of the 1970s. In the last 20 years biotechnology has taken on a revolutionary character due to the development of several fundamentally new production techniques:

1. Fermentation: Production of substances with the aid of micro-organisms, e.g. production of beer and antibiotics.
2. Enzyme technology: Production of substances with the aid of enzymes, e.g. the production of several sweeteners. (The industrial application of enzyme technology has increased

sharply due to the possibility of immobilizing enzymes. This involves fixing enzymes on a solid substance (carrier) so that the enzymes can be continuously re-used.)

3. Cell and tissue culture: Cells and tissues of multicellular organisms are multiplied outside the organisms (in vitro). For example, whole plants can be produced from plant tissue or a single plant cell (regeneration).
4. Genetic engineering: A collection of techniques which enable the genetic material of a living organism to be modified in a manner which goes beyond the natural barriers of mating and recombination. In this way new characteristics can be built into organisms. The techniques for genetic engineering are generally divided into three groups:
   a) Cell fusion: Artificial fusion of cells resulting in new combinations of genetic material. Two examples of cell fusion are:
      - Hybridoma technology: The fusion of an immune cell with a cancer cell, resulting in a hybridoma cell. This technique is used for producing monoclonal antibodies (MAbs).
      - Protoplast fusion: the fusion of protoplasts (somatic plant cell whose cell wall has been removed enzymatically). This technique is used in plant breeding.
   b) Recombinant DNA (rDNA) technology: An isolated piece of genetic material which is produced, by whatever means, outside the cell is inserted into the genome of a host cell through 'cutting' and 'splicing' (by means of enzymes), cloning and recombining DNA sequences.
   c) Other forms: These include all other methods of inserting genetic material such as micro-injection and macro-injection, bacterial or viral infection, electroporation, etc.

While the four groups outlined above are mutually supportive there is one fundamental difference between them. The first three groups as well as traditional biotechnologies were based on the empirical or scientific (after Pasteur) understanding of the characteristics and behaviour of micro-organisms and the deliberate use of the characteristics of each particular organism for the achievement of economic objectives. The last group manipulates the structural and functional characteristics of organisms to overcome their natural limits in performing specific tasks that have economic and social interest. The immobilization of enzymes and cells and genetic engineering are considered the core of "new" biotechnology.

One of the characteristics of new biotechnology is that it is science intensive. In the pre-Pasteur period biotechnology involved the application of practical experiences transmitted from one generation to another. Even with Pasteur and scientific knowledge about characteristics of micro-organisms, technological application remained basically artisanal. Technological innovation arose mainly from the productive sector. The new biotechnologies, on the contrary, are science-based. All major

innovations and discoveries in new biotechnology have occurred in research centres and universities. This aspect, one of the most relevant of new biotechnology, has been the subject of debate. So has been the initiation of a new technological pattern characterised by the increasing association between large corporations and universities either directly or through intermediate firms.[7]

This characteristic poses serious challenges for developing countries. First, it removes biotechnology research results from public access. Second, the linkages between the productive sectors and research centres and universities are particularly weak in developing countries, if not non-existent. Third, research centres and universities in many developing countries have the scientific capacity to participate actively in the development of new biotechnologies and their application to local problems. This, however, requires a change in the science and technology policies of these countries for the creation of linkages in productive and research and academic centres where those links do not exist, or for their strengthening if they already exist.

1.4. Industrial Bias in Biotechnology

There is no doubt that biotechnology holds great potential. However, most of the work so far appears to focus on the industrial-commercial sector at the expense of the agricultural sector. (This development tends to be encouraged by government in developed countries, including the Canadian government.) This reflects the particular problem of industrialised countries. The industrialised countries today are confronted with an agricultural crisis characterised by growing surpluses of food and commodities, which affect prices and increase the burden for governments and consumers alike. Any technological innovation that increases agricultural production is likely to contribute further to this crisis.

Technological innovation, and in particular, basic or radical innovation, play an important role in the industrialised countries in shifting from declining industrial sectors to new ones which slowly assume the role of dynamic forces behind the economic process. An illustration of this is the shift from the steel and coal industry to metallurgy and manufacture of durable equipment and finally, to the chemical industry.

The main purpose of the biotechological programmes of the industrialised countries is to avoid a crisis in the chemical and petrochemical sectors. In this strategy, biotechnology plays a relevant role by creating new products, and new sources of raw materials, and by reducing the vulnerability of the chemical industry, conferring to it a greater flexibility, and reducing its capital-intensive character, by the use of methods less intensive in the use of energy (in particular hydrocarbons). It

favors the relocation of the industry and augmenting the value of natural resources and of activities either based on the production of bulk products of relatively low value added (ethanol) or products of very high value added (pharmaceuticals).

The fact that the industrial potentialities of biotechnology are emphasised, while the agricultural aspects are excluded or considered only marginally, is indicative of the fact that technological development tends to respond mainly to the specific problems of those regions where it originates.

In developing countries the situation is different. Agriculture and food production are the strategic sectors in terms of employment and income generation and distribution. The role of developing countries, it seems, will be the same as traditionally performed, that is, as receivers of equipment, know-how, and new products or traditional products obtained by new processes. These will allow them to supply the centre with raw materials for the new industries which, in turn, will help reduce the centre's dependence on some commodities such as tropical products, fats and oils, protein (soyabean) and so on.

Biotechnological developments will have adverse effects on developing countries in so far as they result in the reduction of international demand for traditional commodities or displaces them by new products resulting from biotechnology diffusion. In this case, employment, income generation and distribution in developing countries will be adversely affected. The crucial issues with regards to biotechnology and development thus are: What potentialities can biotechnology offer and how can these potentialities materialise? What are the conditions to fulfill and the barriers to overcome?

2. IDRC AND BIOTECHNOLOGY

2.1. General Developments

Although biotechnologies are fundamental to many of the projects IDRC has supported,[8] the Centre does not have a well defined biotechnology policy nor a functional definition for biotechnology. Decisions on the use of biotechnological methods or tools in development is left to the Program Divisions which have the responsibility to determine the appropriateness and specific merits of biotechnologies and to recommend whether or not projects in this area should be developed.

There are a number of limitations and consequences arising out of this lack of a clear policy and functional definition of biotechnology, especially in preparing this report. First, there are competing but less than clearly formulated definitions (ranging from basic bioscience research to applied biotechnology

research to down-stream application infrastructure) which are operative across the Divisions. This poses a serious problem for coordinating Centre-wide cooperation as well as keeping abreast with trends and developments in the area. Second, the parameters of the Centre's focus in the area are not easily identified. Third, it is difficult to quantify the number of IDRC projects and DAPs concerned with biotechnology. Biotechnology, for example does not exist as a category in the FAD Management Information System (FADMIS). As a result, there is no easy way to determine FAD DAP expenditures in the area of biotechnology. The same holds true for other Divisions. Finally, the lack of a functional definition makes it difficult to establish the precise nature, focus and scope of current divisional planning processes in the area.

The Centre, in addition to formulating a clear policy, needs to formulate a functional definition of biotechnology, in contrast to adopting a general/universal definition. The multidisciplinary character and the diversity in scope of biotechnology make it difficulties to establishing its boundaries. A general/universal definition would establish boundaries, but it would require ongoing Centre activities in the area to comply with such a definition. This not only would lead to a great deal of confusion and difficulties, but the fit between definition and ongoing activities would be nothing but incidental. Accordingly, a definition should be formulated in accordance with the particular interest regarding the purpose and application of biotechnology in development.

A functional definition should cover and reflect ongoing activities in the area and should be formulated within the context of the Centre's mandate. A useful starting point of formulating a functional definition would be to divide the area into bioscience (basic research), biotechnology (applied research),[9] down-stream industrial-commercial applications of biotechnology research methods/products, and application infrastructure.

2.1.1. The 1985 Report on Biotechnology

The Board of Governors, in light of the above and in response to rapid developments in biotechnology research, in 1983 at the insistence of the then Governor Carl-Goran Heden requested the Centre to prepare an introductory policy paper on the state of the art of the biotechnologies and their relevance to the developing countries.

The Board felt it should have an opportunity to acquaint itself with the subject in order to be able to determine what role, if any, IDRC should play.[10] Specifically, the following issues that were to be discussed:

- Should the Centre depart significantly from the current

practice of treating each case on its individual merits or should it be more active in soliciting proposals?
- Where should the greater emphasis be; on building research capacity or on promoting sound research in countries where some capacity already exists?
- If the field was to be narrowed down by determining certain "program areas" within which IDRC would respond, was this to be done through a multidivisional task force or by creating a separate program area?
- According to which criteria might the field be narrowed down; by type of biotechnology - fermentation, as opposed to genetic manipulation; by sector of potential application - food, health and agriculture, as opposed to industry; by level of research - applied, as opposed to basic exploratory work?[11]

The Report, "Biotechnology: Opportunities and Constraints," presented to the Board of Governors in March 1985 identified the issues before the Board and the Centre as follows:

1. A considerable proportion of what is labelled "biotechnology" has been arrived at empirically. To achieve significant new progress in many sectors requires more fundamental studies. In response, should the Centre devote any of its resources to longer term basic research either in Canada or in developing countries with a demonstrable competence? Or, should support of such research be left to other agencies?
2. While in general responsive to requests submitted by developing countries, a greater or lesser involvement in any sector can be encouraged or discouraged. The Centre can be active, seeking a leading role as it has in selected areas in the past, or it can remain passive, awaiting but not encouraging project proposals.
3. Should the Centre foster the establishment of a data base to cover information about biotechnology applications relevant to developing countries? Or, should the Centre help establish a library/information service comparable to those that exist in American and European companies and make it available to researchers in developing countries?
4. With reference to sectoral choices the Centre has to decide between a few well-chosen, specialized topics of priority interests to developing countries from the variety of different sectors of application -- agriculture, medicine, sanitation, energy, mining and industry.
5. In industrial developments the Centre lacks experienced expertise in the industrial fermentation sector, in biological engineering, in either market research or the marketing of manufactured products. At present it is beyond the Centre's resources to advise in market research or marketing in any branch of industrial fermentation. If however the Centre is encouraged to give greater support to industrial development it must consider seriously how to provide the essential elements of market research.
6. In terms of human resources development the time may have

arrived for the Centre to focus on assisting government planning agencies systematically to assess the present and future supply and demands for skills essential in those sectors of science and technology to which developing countries are given priority, in order to cope with the dangers and constraints of biotechnology research and development which tends to proceed in an atmosphere of secrecy, privatization, industry/university linkages and patenting.

7. Should the Centre concentrate its limited support upon the most advanced; those who can conduct applied research and exploit its results? Or should the Centre have concern for the scientifically less developed and help them over the first hurdle towards developing a relevant and realistic science policy, and to an assessment of the resources they possess and the resources they will need?
8. Finally, the Cooperative Program might examine in what manner Canadian experience and expertise in the area of biotechnology could usefully be made available to the developing world.[12]

The Board after lengthy discussion:

1. agreed that, in the field of biotechnology, the Centre should give priority to projects of applied research,
2. invited the President to ensure that there is, within the Centre, a focal point for biotechnology which will
   (i) monitor developments;
   (ii) evaluate the needs of the developing countries, especially as regards data bases and their effective utilization;
   (iii) advise on the type of projects and activities most likely to be of benefit to the populations of the developing countries, and
3. invited the President to present a further report on biotechnology to the Board in 1987 or 1988.[13]

2.1.2. Recent Developments

Following the 1985 Board Meeting the Centre continued to fund biotechnology related projects but no specific action with regards to biotechnology issues raised in the 1985 Report and the recommendations of the Board of Governors appeared to have been taken. While there is some mention of a "mini-working group maintaining a watching brief on biotechnology"[14] there is no evidence of the emergence of a "focal point" at the Centre that: monitors developments in the area of biotechnology; evaluates the needs of developing countries in the area; and advises on the type of projects and activities most likely to be beneficial to developing countries. At the same time, there is no evidence of a follow up report on biotechnology having been submitted to the Board. The only official Centre activity concerning biotechnology, is an annual report to the Minister of State for Science and Technology (MOSST), prepared by the Office of the

Vice-President (Program), of the Centre's total expenditure in the area of biotechnology.

Evidence seems to indicate that the former Vice-President (Research Programs), Joe Hulse, informally retained an overall awareness of the Centre's activities in the area of biotechnology. He also appeared to have represented the Centre at the ICISTR (Interdepartmental Committee on International Science and Technology Relations) Sub-Committee on Biotechnology at the Department of External Affairs.[15] However, there is no indication that with the retirement of the Vice-President in 1987 that the Centre has maintained it representation on this body. At the same time, centre files on biotechnology appear to end around 1987.

One of the explanations for the limited action in this area appears to have been internal opposition to any specific action with regards to biotechnology as indicated in a memorandum from AFNS to the Vice President (Research Programs). The memorandum argued that; biotechnology is a non-issue; it should not be a central point; AFNS does not plan to support research on biotechnology techniques; elevation of this subject matter to a target for specialized institutes, programs, or divisions, whether inside or outside IDRC should be discouraged; if there are policies to be set, this can be done with the existing divisions and if the general consciousness of the Centre needs to be raised, this again will have to be done through the divisions' staff; although the Centre should provide leadership in research priority setting and in encouraging appropriate ways to conduct research, biotechnology is an appropriate subject. On the contrary, research driven by a particular technology or instrument should continue to be discouraged."[16]

There appears to have been a recent change in climate with regards to biotechnology. This change in climate is due to a number of factors of which the most important is the arrival of a new Director in AFNS.

As well, there seems to be a growing awareness of the potential as well as of the consequences of biotechnology for the developing countries. There is a growing awareness and need expressed for the Centre to keep abreast with developments in biotechnology research in order to assess the opportunities as well as the constraints of biotechnology for developing countries. Information on recent developments in biotechnology has been gathered on an individual basis in various divisions throughout the Centre.

Nowhere are these changes more evident than in AFNS. In a recent memorandum to the Vice-President (Program), AFNS raises some of the issues of biotechnology and development; its potential contribution to development; the danger of increasing the North-South gap; ways to ensure that LDC's benefit from recent advances; the establishment of mechanisms that encourage

biotechnological innovation of relevance to LDC's through appropriate reward systems; the limited information on developments in biotechnology research and application in developing countries at the Centre; and the very limited biotechnology expertise of the Centre staff.[17]

More importantly, at a Centre-wide level, the Office of the Vice-President (Program) has built into the Program Committee Workplan a seminar process which will have as its first topic biotechnology. It is expected that this seminar process will lead to a position paper on biotechnology that will be presented to the Program and Planning Committee of the Board of Governors.

2.1.3. Issues

Some of the key issues raised within the context of preparing this report were: The Centre in certain areas of biotechnology research is not keeping up with some of the developing countries, especially those in Southeast Asia and South and Central America: The Centre has little contact with biotechnology research in Canada: The Centre has little insight into the size of national science and technology/biotechnology programs in developing countries and demands for biotechnology: There is need for a clearly defined definition and a coherently formulated policy of biotechnology: There is a growing need to gather up-to-date information on developments in the various areas of biotechnology research to assess opportunities and consequences, and to provide information and advice for developing countries on the possibilities, limitations and constraints of biotechnology: There is a need for more risk analysis, and analysis of trends in, and socio-economic and environmental consequences of biotechnology research, as well as more longer-term planning: There is a growing need for more in-house expertise and education in the area of biotechnology.

The more immediate questions arising out of these issue are: What is the definition and range of biotechnology research issues for development? Who is supporting work in this area, and who are the users of biotechnology knowledge? How does IDRC itself make use of biotechnology research? What developmental trends are taking place within the area? What gaps, changing demands and opportunities and constraints exist in the field to which IDRC must be alert? What policy options must be derived for IDRC in terms of future focus, resources, structure and mechanism?

2.2. Divisional Developments

2.2.1. Agricultural, Food and Nutrition Sciences Division (AFNS)

1. Current Planning Process

The Agricultural, Food and Nutrition Sciences Division plans

to increase funding for biotechnology projects in order to bring these "new tools" to developing countries. Recognizing the importance of coming to grips with developments in the area AFNS has contracted MTL Biotech (Victoria, B.C.) to undertake an in-depth review of Canadian biotechnology expertise of relevance to developing countries. The study is designed to assist AFNS in the development and application of a policy on biotechnology commensurate with the Centre's objectives in the Third World. AFNS also is in the second phase of a project on Plant Breeders Rights: evaluating Canadian patent rights legislation (i.e., gene patenting) and its impact on research in Canada, in developing countries, and on farmers. Moreover, AFNS is in the planning stage of upgrading personnel skill and awareness in the area biotechnology, and of formulating strategic positions in selected areas of biotechnology research in agriculture.

2. Initiatives/Discussions

AFNS has undertaken no initiatives or discussion with the Canadian academic/research community or private sector in the area of biotechnology outside of ongoing or completed projects and DAPs.

3. Committees/Reporting Requirements

AFNS sits on a committee of the Multilateral Affairs Division of Agriculture Canada that focuses on plant genetic resources development globally. AFNS is under no obligation to report on its activities in the area of biotechnology.

2.2.2. Communications Division (COMM)

The Communications Division has no current divisional planning processes in the area of biotechnology. Moreover, the Division has undertaken no discussions or initiatives with the Canadian academic/research community or private sector with regards to biotechnology. The Communication Division is not represented on any committees at the national level and has no reporting requirement on activities in the area of biotechnology.

2.2.3. Earth and Engineering Sciences Division (EES)

1. Current Planning Process

The focus of the Division is on the urban poor, on making better use of local products and local waste, and on utilizing science and technology in development. Within this context, the Division's focus on biotechnology is comparative with chemical and mechanical processes.

EES is very positive on biotechnology and would like to see Centre-wide cooperation in the area, i.e., central information gathering to keep abreast of global developments in biotechnology research, made available to all divisions. The Division's major problems in the area of biotechnology are finances and experienced staff. EES lacks expertise in biotechnology. A relatively new division EES, in building up its manpower requirements, was caught up in the federal government's budget cuts.

EES currently is undertaking a review of its Technology for Local Enterprise Program that is to serve as the basis for the Division's policy on science and technology, and ultimately its biotechnology policy. Moreover, an understanding in principle has been reached with AFNS to develop a joint sub-program on Post Production Systems (PPS) with a focus on biotechnology.

2. Initiatives/Discussions

There are no initiatives or discussions with the Canadian academic/research community or private sector with regards to biotechnology.

3. Committees/Reporting Requirements

The Division is not participating in any committees at the national level and has no requirement to report on activities in the area of biotechnology.

2.2.4. Fellowships and Awards Division (FAD)

1. Current Planning Process

Fellowships and Awards does formal and informal training in biotechnology related fields. While FAD focuses on science and technology, there is no special focus nor a divisional planning process for the area of biotechnology. FAD training activities are mainly in response to requests from other Centre divisions.

2. Initiatives/Discussions

FAD has undertaken no discussions or initiatives with the Canadian academic/research community or private sector with regards to biotechnology.

3. Committees/Reporting Requirements

The Division is not participating in any committees at the national level and has no requirement to report on activities in the area of biotechnology.

2.2.5. Health Sciences Division (HS)

1. Current Planning Process

The Health Sciences Division views biotechnology as a tool to aid development in certain instances and will use biotechnological tools in projects where they are appropriate. To date 10-15% of HS support is invested in the use of biotechnological methods. HS's focus on biotechnology is primarily in the area of diagnostics and contraceptives.

While biotechnology tools may be used more frequently in the future, there is no special focus in the area of biotechnology at HS. The focus of HS is to build capacity in the health sciences in developing countries to the benefit of the poor. Its primary focus is on getting existing solutions to the problems. The feeling is, there are not that many outstanding problems in the field of human health care that call for new biotechnological solutions.

HS supports very little development of biotechnological capacity in developing countries. For the moment, HS is not considering proposals for biotechnology development in developing countries. The Division is interested in determining more clearly the benefits of biotechnology for the poor in the field of health care. Within the Centre, there are discussions underway for closer cooperation with AFNS in area of biotechnology in pest control.

2. Initiatives/Discussions

While there are no specific initiatives or discussions in the area of biotechnology, HS has ongoing discussions with the Canadian academic/research community and the private sector (e.g., with Connaught Laboratories in the area of vaccineology and diagnostics).

3. Committees/Reporting Requirements

The Division is not participating in any committees at the national level and has no requirement to report on activities in the area of biotechnology.

2.2.6. Information Sciences Division (IS)

1. Current Planning Process

Information Sciences has no specific planning process in the area of biotechnology. The Division is currently formulating a strategy for the 1990s in the larger area of science and technology. Within this context biotechnology is viewed as an important aspect of development. The focus is on improvements in the flow of information from source to use in order to

give researchers, policy-makers, and practitioners in developing countries access to scientific and technical information and information technologies.

The major thrust of the Division is to link the scientific communities in developing countries, and to link them to the "invisible college" of the scientific community of the developed countries. Within this context IS is looking at the possibility of regional networks in biotechnology.

2. Initiatives/Discussions

IS has undertaken no initiatives or discussions with the Canadian academic/research community or private sector with regards to biotechnology.

3. Committees/Reporting Requirements

The Division is not participating in any committees at the national level and has no requirement to report on activities in the area of biotechnology.

2.2.7. Social Sciences Division (SSD)

1. Current Planning Process

Currently, there is no special focus on biotechnology in the Division. However, SSD has a keen interest in ethics and risk analyses in the area of biotechnology and development. It regards these issues as crucial and in need of serious attention.

The Division has an ongoing project that looks at biotechnology within the larger framework of science and technology in development. "Technology Perspectives (Latin American)" looks at issues of new technologies in development in order to formulate a long-term scientific and technological strategy for the region. Phase II of the project focuses on identifying existing scientific and technological capabilities, the main trends of current technological change, and feasible socio-economic, political and technological strategies for countries in the region to use creatively to incorporate the new wave of technological innovations, including biotechnology.

Moreover, the Division is holding talks with AFNS on cooperation in the area of socio-economic consequences of biotechnology in agriculture, i.e., socio-economic consequences of the introduction of new and improved crops for developing countries.

2. Initiatives/Discussions

SSD has undertaken no discussions or initiatives with the Canadian academic/research community or private sector with regards to biotechnology.

3. Committees/Reporting Requirements

The Division is not represented on any committees at the national level and has no requirement to report on activities in the area of biotechnology.

3. CANADIAN INITIATIVES IN BIOTECHNOLOGY[18]

3.1. Developments at the Federal Level

Canada, as most other developed countries, recognizes biotechnology as a priority for research and development leading to new opportunities for future industrial growth. In 1980, the Ministry of State for Science and Technology (MOSST) established a Task Force on Biotechnology to advise the Minister on development of an effective Canadian strategy for promotion of biotechnology. The task force recommended a long-term federal funding commitment, industry stimulation through tax incentives and technology transfer from government and university laboratories, and increased financial support to the Medical and National Research Councils (MRC and NRC) for interdisciplinary research, development and training.[19] Priority research areas were identified in nitrogen fixation, plant strain development, human and animal health care products, mineral leaching and metals recovery, forestry and forest products, waste treatment, and fisheries/marine aquaculture.

This National Biotechnology Strategy was adopted in 1983 by the federal government. The Strategy is administered by the Technology Policy Branch of the new Department of Industry, Science and Technology Canada (ISTC). Also in 1983, a National Biotechnology Advisory Committee, comprised of government, industry and university representatives, was established to advise the Minister on new developments and policy requirements in biotechnology. The Advisory Committee's annual reports are published by ISTC. A federal Interdepartmental Committee on Biotechnology (ICB) was established, chaired by ISTC, to review proposed federal government activities and monitor progress under the new National Biotechnology Strategy.

Significant activities have included establishment of Biotechnology Networks to promote communication among researchers in each of the priority research areas. Each Network is administered by a federal department and membership is open to anyone interested in the development and application of

biotechnology in a particular sector (for a listing of the Networks see Appendix C).

Moreover, the government implemented a Biotechnology Development Program administered by the National Research Council through the Industrial Research Assistance Program (IRAP). Under the Program, which is designed to encourage technology transfer to the industrial sector, companies are eligible for financial support providing they are accessing technology developed in universities, federal laboratories or Provincial Research Organizations. Technology transfer through international collaboration may also be funded.

By the end of the 1987-88 fiscal year, the Programme has supported 81 projects involving 63 biotechnology companies in collaboration with 22 universities and two provincial research organizations. The total value of the R&D projects funded between 1983, when the programme was launched, to the end of 1987-88, was $42.6 million, with the Federal Government contributing 57% ($24.4 million). Of the 81 projects 31 were in health which received 39% of the expenditure; 24 were in agriculture with 27% of total expenditure; food 13 (11%); cellulose/waste 5 (9%); mining 2 (7%); and 6 others (7%).

The federal government also strengthened its biotechnology research capacity. It established two new research institutes under the auspices of NRC: The Biotechnology Research Institute (BRI) in Montreal, which focuses on industrial biotechnology, on medical and pharmaceuticals and on genetic engineering; and the Plant Biotechnology Institute (PBI) in Saskatoon, which assists private sector companies with biotechnology development involving plant cell technology and plant genetic engineering.

Agriculture Canada has expanded its activities in plant, animal and food biotechnology. Other federal departments such as Health and Welfare, Energy, Mines and Resources, and Fisheries and Oceans have their own biotechnology programs and the federal granting councils provide support for research carried out at Canadian universities. Finally, the department of External Affairs, through the Interdepartmental Committee on International Science and Technology Relations (ICISTR) Sub-committee on Biotechnology, provides a forum for the coordination of federal efforts in biotechnology with the international community in this field.

3.2. Federal Regulatory Framework

Current legislation applicable to biotechnology in Canada pertains to specific product categories, without regard to the process of production. These product categories include veterinary biologics, pest control products, foods, drugs, cosmetics and medical devices. Other products intended for environmental use, such as waste treatment of mineral leaching,

or waste products unintentionally released to the environment, are addressed by the Canadian Environmental Protection Act (CEPA). Research activities without a clearly defined end product can be regulated under CEPA.

Canadian guidelines for handling recombinant DNA, animal viruses and cells were developed in 1977 by the Medical Research Council.[20] The guidelines specify appropriate levels of containment for micro-organisms, including viruses, according to the toxin, the degree of pathogenicity, and the nature of the research. They were revised in 1979, and again in 1980, with progressive relaxation justified by continued safe experience and consistent with international views.[21] MRC guidelines clearly apply to laboratory research (culture quantities up to 10L) and are not intended to address procedures for field trials or open environmental release. Notification of MRC is required only in MRC funding applications. Guidelines are not enforced by MRC, except by withholding of funds.

The major federal statutes applicable to products of biotechnology are administered by Health and Welfare Canada, Agriculture Canada and Environment Canada.[22] The provinces and territories play a prominent role in regulation, sharing responsibility with the federal government for environmental protection, and having primary responsibility for occupational health. Occupational health legislation is the only type of regulatory instrument that could be used at present for control of research activities. Most research activities adhere closely to MRC guidelines, although the guidelines are voluntary. Provincial environmental legislation is generally modeled after federal instruments, and usually lacks pre-manufacture notification requirements, or specific penalties for violation. Applicability to biotechnology products or wastes is uncertain, and may vary from province to province.

In 1985, the Interdepartmental Committee set up a Sub-Group on Safety and Regulation, co-chaired by Health and Welfare Canada and Environment Canada, to examine safety and regulatory issues in biotechnology, and advise on the adequacy of the regulatory system if required. In addition, the federal government has started a consultative process with the provinces to arrive at a coordinated national approach to biotechnology regulation.

Individual federal agencies are also reviewing regulatory positions, instruments and responses in order that they will be able to deal effectively with new technological developments. The Medical Research Council has established a subcommittee, jointly with Health and Welfare, reporting to the MRC's Standing Committee on Ethics in Experimentation for review of MRC Guidelines with respect to new developments in biotechnology. National Health and Welfare has established a Biotechnology Committee within the Health Protection Branch to examine all aspects of biotechnology that impinge on Branch activities, including reviews of federal health protection legislation.

Agriculture Canada has identified the need for an advisory panel on biotechnology to review regulatory responses related to veterinary biologics. Environment Canada, in conjunction with the Department of National Health and Welfare, administers the new Canadian Environmental Protection Act (CEPA) which was passed in June 1988. CEPA subsumes the old Environmental Contaminants Act which was remedial rather than preventative in approach and precluded regulation of living organisms. The definition of a substance under CEPA, 'any distinguishable kind of organic or inorganic matter, whether animate or inanimate...', is sufficiently broad to include products of biotechnology. CEPA is covering safety in the research, production, use and disposal of products. Pre-manufacture notification is required under this Act.

Provincial agencies are also in the process of reviewing their regulatory positions pertaining to biotechnology. For example, Ontario and Alberta have established interdepartmental committees to study their respective regulatory regimes and Manitoba is actively consulting with industry. The provinces are supportive of consistent national action and look to the federal government to provide scientific information and criteria to aid in setting policies

Canada has also been very active in the OECD work on safety and regulations, and is supportive of the OECD proposals for the international harmonization of regulations related to biotechnology.[23] A joint Canada/OECD workshop on biotechnology, held in Toronto in April 1987, highlighted the importance of public confidence in the regulation of biotechnology, and supported the creation of an international data base for regulatory and risk assessment criteria and information.

3.3. Canadian Biotechnology Industry

According to the government's 1988 Canadian Biotechnology Industry Sourcebook, the number of commercial companies actively involved in researching or using biotechnology research in Canada had grown from 110 in 1986 to 218 by 1988. Companies actively involved in biotechnology are concentrated in the health care sector followed by agriculture and waste treatment.

The majority of companies indicated that application of their biotechnology activities are pertinent to multiple sectors. However, in the health care sector 49% of the reporting companies claim applications for research unique to their sector; in agriculture the similar figure is 27%; for all others (aquaculture, chemicals and alternative energy; mineral resources; food and beverages; forestry and forest products; waste treatment) less than 20% of the companies involved have applications which are unique to one sector.

On the basis of confidential as well as published information provided by 173 companies, there are 1478 persons involved in biotechnology and 174 companies reported R&D expenditure to be approximately $164 million. There are estimated to be almost 1850 persons involved in biotechnology in Canada and annual expenditures for R&D are approximately $200 million or double the figure of 2 years ago. There has been an obvious growth in terms of expenditures and numbers of personnel involved in biotechnology since the release of the 1986 sourcebook: indeed, the number of companies involved in biotechnology R&D between 1986 and April 1988 has increased 16%.[24]

4. DONOR AGENCIES AND INTERNATIONAL INSTITUTIONAL INITIATIVES[25]

In the process of establishing a special programme on "Biotechnology and Development Cooperation" the Directorate-General for International Cooperation (DGIS) of the Netherlands in 1988 carried out an inventory study of biotechnology policy and activities of donor agencies and organizations. The study surveyed seven (7) donor country agencies, the Rockefeller Foundation and the European Community, thirteen (13) United Nation agencies, the World Bank and three (3) regional development bank as well as thirteen member institutes of the Consultative Group on International Agricultural Research (CGIAR).[26]

An examination was also made the sectors where biotechnology was primarily used (agriculture and fisheries, human health care, environmental protection, energy, mining and industry) and the type of activities (technological research, training and education, physical capacity-building, socio-economic studies, information supply and advisory services).

The biotechnology policy of the different organizations varies widely. While some organizations already have a biotechnology programme for the benefit of developing countries, others still devote hardly any attention to biotechnology. The most active organizations include USAID, the Rockefeller Foundation, the UN agencies ILO, UNESCO, UNEP and UNIDO, and many of the IARCS (International Agricultural Research Centres) of the CGIAR. Many donors (e.g., ODA, DANIDS, SAREC, CIDA, EC, IAEA, UNCSTD, UNCTAD, WFP, WHO, WIPO, AfDB, ADB and IDB) do not devote any special attention to biotechnology and developing countries. There are indications that several donors like ATSAF, DGIS, FAO, IFAD, UNDP and WB are currently formulating a biotechnology policy for the Third World. There is no international coordination at present.

Most of the organizations which are active in the field of biotechnology have technological research projects, notably in

agriculture (arable farming and animal production), human health care and industry. Few research activities were reported in the environmental protection sector, and no activities in the energy and mining sectors. In addition to technological research, a great deal of attention is devoted to training and education. Especially UN agencies undertake activities in the field of socio-economic studies, information supply and advisory services.

4.1. National Donor Agencies

At present only USAID and the Rockefeller Foundation have a special programme on biotechnology for developing countries. USAID has an extensive biotechnology programme in which the development and application of biotechnology as well as the building up of national research capacity in developing countries are priorities. USAID has recently formed a Standing Committee on Biotechnology to provide advice on the technical, regulatory and programmatic issues surrounding biotechnology and to develop mechanisms to address these issues. The Committee serves as liaison with other US agencies more substantially involved in supporting and regulating biotechnology.

The Rockefeller Foundation in 1984 set up a special biotechnology programme in the framework of its science and technology policy. The goals of the programme are: to assure that new techniques of crop genetic improvements based on advances in molecular and cellular biology are developed for rice; to facilitate the transfer of these biotechnologies to rice breeding programmes in the developing world for use in producing improved varieties that address priority needs; and to help build the scientific research capacity necessary for continued development and application of new rice genetic improvement technologies in selected developing countries.

Other donor agencies such as ATSAF (Federal Republic of Germany) and DGIS (The Netherlands) are holding consultations on the possibility of setting up such a programme. The other donors do not yet have any plans to draw up a definite policy on biotechnology for the Third World. Several of them, ODA (United Kingdom), SAREC (Sweden) and European Commission do, however, have activities in this area.

Most biotechnology activities are concerned with the agricultural sector and involve technological research and the following subjects: (1) plant cultivation and improvement (tissue culture and genetic engineering); (2) BNF by means of Rhizobium; (3) diagnosis of animal and plant diseases (MAb test and DNA probes); and (4) animal nutrition (bioconversion of agro-industrial and agricultural waste). There are also several technological research projects in the human health care sector. These generally involve diagnosis (MAb tests or DNA probes) of diseases such as diarrhea and malaria. In addition to technological research, a great deal of attention is devoted to

training and education in the field of biotechnology.

4.2. UN Agencies

The extent to which attention is devoted to biotechnology for developing countries varies widely between the different UN agencies. Agencies such as ILO, UNESCO, UNEP and UNIDO already have extensive biotechnology programmes.

ILO is actively and continuously monitoring the socio-economic effects of the advanced biotechnologies with the aim of: (a) determining the socio-economic impact of introducing specific biotechnologies designed to improve the production of major food and cash crops; (b) assessing the capacity of existing extension structures to disseminate new biotechnologies to small farmers; (c) improving understanding of structural changes in rural employment induced by the biotechnology revolution. The ILO's approach is to identify policies and measures, at both national and international level, in order to promote biotechnology's potential for helping the poor in developing countries, and to rectify negative developments. ILO also has a focus on workers' safety and occupational health.

UNESCO has been active in the field of biotechnology for a long time. Its focus is on the formulation of policies and the development and strengthening of infrastructure in the field of biotechnology. It has emphasized the need for elaborating national policies for research in biotechnology and its application. This has resulted in the establishment of: (1) Global network of Microbiological Resources Centres (MIRCENs) in collaboration with UNEP and the International Cell Research Organization (ICRO) in 1974. The primary focus of the MIRCENs is to enhance the quality of human environment and the life of the humans in the developing areas of Asia, Africa, and Latin America by bringing into play the full potential utility of micro-organisms; (2) Regional Programme of Biotechnology for Latin America and the Caribbean in collaboration with UNIDO and UNDP (1987-1991). This programme promotes collaborative applied and basic research, training, and development of biotechnologies and products, and their industrial application and commercialization. The programme also aims at mobilizing financial and technical support from developed countries for this purpose. The programme is divided into two subprogrammes: 'basic development of biotechnologies and products' and 'technological development and industrial application of biotechnology'. UNESCO is responsible for the first subprogramme which involves activities regarding laboratory R&D and training of human resources in basic scientific disciplines of biotechnology to support scientific-technological developments. UNIDO is responsible for the second subprogramme.

UNEP has been active in the field of biotechnology since the 1970s. It has gradually expanded its activities in the field of

applied microbiology and biotechnology. The central objective is the use of these technologies for environmental protection in developing countries and for the conservation of biological diversity. UNEP is currently involved in a large number of biotechnology activities, either on its own or in collaboration with other organizations. The projects mainly involve technological research and training.

UNIDO has an elaborate biotechnology policy for the benefit of developing countries. Its major goal is the development of national capacity-building in developing countries and to solve some of the constraints and problems faced by the developing countries in their biotechnology efforts. UNIDO has established two specific biotechnology programmes: (1) International Centre for Genetic Engineering and Biotechnology (ICGEB). ICGEB, established in 1983, is divided into two centres, one located in Triest, Italy and one in New Delhi, India. The centre in New Delhi concentrates on agriculture and health. The Italian half of ICGEB focuses on industrial microbiology. Training of scientific and technological personnel from developing countries represents a key element in ICGEB's activities. In addition ICGEB if the focal point in a network of affiliate regional and national research and development institutes, where work of special interest will be carried out; (2) Regional Programme of Biotechnology for Latin America and the Caribbean in collaboration with UNESCO and UNDP (1987-1981). UNIDO, as mentioned above, is responsible for the second subprogrammes, 'technological development and industrial application of biotechnology', which involves projects regarding the invention and evaluation of technologies and the upgrading of human resources for industrial application of biotechnologies.

Others UN agencies do not yet have any plans to formulate a policy on biotechnology. Several of them (IAEA, WHO, and WIPO) do, however, have many activities in this field. FAO, IFAD and UNDP are currently formulating a specific biotechnology policy or intend to do so in the near future.

Most biotechnology activities involve the sectors agriculture, human health care and industry. Technological research projects in the agricultural sector mainly focus on the following fields: (1) plant cultivation and improvement (tissue culture and genetic engineering); (2) BNF by means of Rhizobium; (3) biological control of pests (Bacillus thuringiensis and genetic sexing of insects); (4) animal health care by means of development and production of diagnostic tests (MAb tests and DNA probes) and vaccines (rDNA technology); (5) animal breeding (ET); and (6) improvement of animal nutrition (bioconversion of agro-industrial and agricultural waste). In the human health care sector, the emphasis is on the development and production of diagnostic (MAb tests and DNA probes) and vaccines (rDNA technology). There are few research projects in the field of environmental protection, and no research activities were reported in the energy and mining sectors.

The nature of the activities varies widely. In addition to technological research, attention is devoted to training and education, physical capacity-building, socio-economic studies, information supply, and advisory services. It should be mentioned that UNIDO is the only UN agency which publishes a biotechnological research monitor regularly with the objective to sensitize scientists and policy-makers.

4.3. Development Banks

The approach taken by the development banks is more or less the same. At present none of the banks mentioned has a biotechnology policy, but they do not rule out the possibility of formulating one in the future. The World Bank has already taken concrete steps in this direction.

The World Bank is currently sponsoring a study of the application of biotechnology in developing countries, with a view to determining how the Bank should invest in biotechnology and for what purpose. The aim of the study is to identify the opportunities and constraints for the application of biotechnology in developing countries, and to develop a strategy for public sector investments in biotechnology of relevance to national agricultural research systems (NARSs) and development agencies. (The study is being co-financed by the World Bank and the Australian Government, and is being undertaken jointly by the World Bank, the Australian Centre for International Agricultural Research (ACIAR), and the International Service for National Agricultural Research (ISNAR).)

Biotechnology activities are mainly conducted in the agricultural sector (arable farming). Virtually no activities were reported in human health care, environmental protection, energy, mining and industry. Attention is mainly devoted to training and physical capacity-building.

4.4. Consultative Group on International Agricultural Research (CGIAR)

CGIAR has recently adopted a provisional biotechnology policy which recommends that biotechnology research of the Centres should be geared to solving problems and not to the development of new techniques. Besides, more strategic (up-stream) research should be acquired from highly specialized institutes and universities. Moreover, cooperation with the private sector is considered important. (It should be mentioned that the Director of AFNS, Geoffrey Hawtin, is a member of a CGIAR task force on biotechnology chaired by The Netherlands, which is concerned with legal and policy issues.)

All technological research institutes of the CGIAR mentioned make use of biotechnology. The IARC's biotechnology activities

all lie in the agricultural sector, of course, notably in the field of tissue culture and disease diagnosis (MAb tests and DNA probes). The institute which is most active in the field of rDNA technology (vaccine development) is ILRAD. Other institutes such as IBPGR, ICRISAT, IITA, LICAT and IRRI also make use of rDNA techniques; this often involves gene mapping. In addition to technological research, a great deal of attention is devoted to training. Occasionally, socio-economic studies are carried out, although specifically recommended by TAC. No reply was received from "Centro Internacional de la Papa" (CIP).

5. TRENDS AND ISSUES

Biotechnology, because of its nature and its potential, trends in biotechnology research, and the issues arising from them requires special consideration beyond the more general framework of science and technology. There are obvious short-term considerations arising out of the nature of biotechnology, its opportunities and constraints for development, and trends in biotechnology research. Then, there are more fundamental and longer-term considerations arising out of the potential of biotechnology with regards to globally sustainable development and global environmental concerns.

Biotechnology could put an end to famine and diseases, solve problems of waste disposal, deforestation, and high energy costs. Further, biotechnology is readily adapted to the specific conditions prevailing in developing countries. Its applications are often uncomplicated and non-capital intensive and do not usually require much energy.

But, biotechnology may also have predominantly negative socio-economic consequences for developing countries (e.g. substitution of raw materials, industrialization of agriculture and technology privatization) which are compounded by their economic weakness and limited legislation.

Its nature (basic research in biotechnology is science-intensive) and trends in biotechnology research (privatization and an industrial-commercial bias in research, and patenting and restricted access to processes and products) will make it difficult for developing countries to make optimum use of the potential offered by biotechnology. The use of biotechnology in developing countries is largely dependent on the present and future balance of power in the area. There is a high risk of developing countries becoming even more dependent on the industrialized countries.

In light of the nature and the extent of the possible effects of biotechnology on developing countries one cannot but concur with the view of the Report by The Netherlands' Directore-

General for International Cooperation on "Biotechnology and Development Cooperation":[27] Biotechnology, its research, application and consequences should not be neglected by those responsible for development cooperation. Donor countries and organizations, should consider developing a specific policy on biotechnology and development. The important issues are; how to secure access of developing countries to biotechnological knowledge and technology; how to use biotechnological technologies to assist in solving critical problems in developing countries; and how to minimize the negative effects of biotechnology on developing countries.

In addition, more attention should be devoted to socio-economic analyses, technological assessment, risk assessment regarding environmental release of genetically engineered organisms in developing countries. Attention should focus on the need for information supply on current biotechnological developments directed towards policy-makers, development workers and researchers in both developed and developing countries. Moreover, there is a need for greater coordination and cooperation of donor agencies and organizations with the aim of establishing joint programmes on specific issues in biotechnology and development.

The challenge to donor agencies and organizations and the developing countries is to devise innovative mechanisms to facilitate the transfer of technology from the private sector in industrialized countries to both the public and the private sector in the Third World under mutually beneficial arrangements.

The challenge for IDRC, if it is to be a serious player in biotechnology and development, is to keep abreast with trends and developments in biotechnology research. The Centre has to be more actively involved in gathering information in a systematic manner on international developments in the area of application of biotechnology in Third World countries.

The Centre needs to focus more on longer-term socio-economic and environmental impact and risk analyses with regard to the opportunities, constraints and consequences of biotechnology on developing countries. The Centre must facilitate more actively the North-South and South-South information flow in the area of biotechnology. The Centre further needs to consider expanding its role to advise developing countries on appropriate biotechnologies for development.

In order to take on this mandate the Centre needs: critical in-house scientific expertise to monitor, choose and utilize new products and processes and adapt them to the real limiting factors in developing countries; skills to acquire new technologies from the public or private sector in industrialized countries, under mutually suitable licensing and/or royalty arrangements for the benefit of developing countries; the capacity to integrate new technologies into existing R&D

programs; and the skills to identify and develop well-chosen and effective collaborative research programs with public and private sector laboratories in developed and developing countries.

Beyond the obvious short-term considerations there are more fundamental longer-term issues arising out of the potential of biotechnology within the context of globally sustainable development and global environmental protection.[28]

Given the present direction of industrial development, it is anticipated that as we approach the 21st century, humankind will be confronted with an increase in environmental problems on a global scale, the exhaustion of available natural resources, and the need to conquer incurable diseases, a rise in the incidence of stress due to a highly scientific and technological society, a growth in population, the advent of an aging society and so on.

Extending the existing boundaries of science and technology will not be sufficient to solve these problems. It will be necessary to make new efforts to build up new modes of science and technology and models of development in harmony with nature and human society and to carry out fundamental reform of existing science and technology and development pattern.

The elucidation of the superior biological functions (through bioscience/biotechnology research) will contribute to the development of science and technology in harmony with nature and human society. It could be the seeds for the development of future science and technology, the promotion of which from a long-term viewpoint will be significant.

Existing science and technology are large scale and are based on high temperature, pressure and speed and are high in energy consumption. Bioscience/biotechnology research could possibly result in the fundamental reform of existing science and technology making it kinder to human beings in such a way that it will be distinguished for its saving of energy and resources and lack of pollution in harmony with the natural environment and human society.

Securing food and forestry resources and conquering incurable diseases are problems which are common to many Third World and other countries. The elucidation of the superior biological functions should produce sufficient basic answers to enable these various problems to be dealt with and eventually to be overcome.

Without a question, it is mainly the deeply rooted traditional industrial development pattern and underlying value structure of the developed countries that has led to the growing destruction of our natural habitat. However, this destructive structure and pattern of socio-economic interaction and its governing value structure are not easily transformed. Thus, the question has to be; to what extent do our hopes lie with

developing countries adopting a more beneficial pattern of social and economic development? Of developing countries taking the lead in spearheading development more in harmony with nature and human society?

The challenge for donor agencies and organizations is to encourage, assist and facilitate an alternative development in the Third World, not only for the benefit of the poorest of the poor but for the benefit of all of humankind. Given their specific location, they are in a unique position to critically influence future global developments. With their global connections in the development community, the academic and research communities in both developed and developing countries, donor agencies and organizations such as IDRC are in a position not only to formulate a bold new vision of global development that must start with the developing countries, but to shape and influence the necessary rethinking and debate in the global community.

In order to take up this challenge donor agencies and organizations need to rethink and reconceptualise traditional views of development. They need to focus beyond the narrow confines of locally sustainable development and local environmental protection on globally sustainable development and global environmental protection. Further, they need to refocus from the limited focal point of the poorest of the poor in the Third World to poverty and environmental destruction on a global scale.

IDRC, given its broadly defined legislative mandate,[29] is in a unique position, within the context of formulating a position on biotechnology, to take the lead in rethinking and reconceptualising development and in encouraging, assisting and facilitating the start of an alternative development in the Third World.

Some of the fundamental questions for the Centre within this context will be; what model of development does the Centre currently support and what are the consequences of this kind development for the rural poor, developing countries, and globally? What type of development should the Centre support and encourage in the Third World?

6. RECOMMENDATIONS

In view of the nature and extent of the possible effects of biotechnology on developing countries and in light of the observations and findings of this Report the following recommendations are made:

The Centre, within the context of its traditional

activities, should:

1. Adopt a clear policy and an operational definition of biotechnology.

2. Implement the 1985 Board decisions on biotechnology.

3. Resume its role in the ICISTR Sub-Committee on Biotechnology (External Affairs).

4. Upgrade Centre personnel skill and awareness in the area of biotechnology.

5. Gather, in a more systematic and institutionalized way, up-to-date information to assess opportunities and constraints of developments in the various areas of biotechnology research for developing countries.

Going beyond its traditional activities the Centre, within its broadly defined legislative mandate, should:

6. Develop in house capabilities and focus on longer-term socio-economic and environmental impact and risk analyses with regard to the opportunities and constraints of biotechnology for developing countries.

7. Expand its role, in cooperation with other donor agencies and organizations, to advise developing countries on appropriate biotechnologies for development.

8. Rethink and reconceptualize, within the context of formulating a position on biotechnology in development, its traditional view of development; expand its focus beyond the narrow confines of locally sustainable development and local environmental protection to globally sustainable development and global environmental protection; and expand the focus from the poorest of the poor within their setting of the Third World to a focus on their conditions within the larger global socio-economic and environmental context.

References

1. This section is based on and contains portions of a report by the Directorate-General for International Cooperation of the Netherlands on "Biotechnology and Development Cooperation" (February 1989) and a working paper prepared for the ILO World Employment Programme Research (Pablo Bifani, "New Biotechnologies for Rural Development," ILO World Employment Programme Research Working Paper WEP 2-22/WP 195, January 1989).

2. European Federation of Biotechnology, Report on Founding Conference, 1981.

3. FAST (Forecasting and Assessment in Science and Technology), Directorate-General for Science, Research and Development, Commission of the European Communities. See also M.F. Cantley, "Plan by Objective," FAST, CEC, Brussels, January 1983, and M.F. Cantley, "Biotechnology: What will it change?" FAST Occasional Papers No. 1, March 1981, Commission of the European Communities, Brussels.

4. U.S. Office of Technology Assessment, Commercial biotechnology: An international assessment (Washington D.C.: U.S. Government Printing Office, 1984).

5. A.T. Bull, G. Holt and M.D. Lilly, Biotechnology: International Trends and Perspectives (Paris: OECD, 1982).

6. Ministry of State for Science and Technology, "Federal Expenditure for Biotechnology 1981-1986," Biotechnology Unit, Industrial Support and Strategic Technology Branch, October 1986.

7. See Gerardo Otero, "Industry-University Relationship and Biotechnology in the Dairy and Sugar Industries: Contrast between Mexico and the United States," ILO World Employment Programme Research Working Paper WEP 2-22/wp 192, January 1989.

8. Over the last two decades approximately 9% (351) of all IDRC projects (3997) and about 14% ($97 million) of all IDRC expenditure ($709 million) have been in biotechnology related projects. In the period from 1985 to 1989 the number of biotechnology related projects has declined to 7%, while expenditure on biotechnology related projects fell to 11%. The Agriculture, Food and Nutrition Sciences Division with $81,241,386.00 (81%) has spent the lion's share of the total expenditure in biotechnology related projects; Health Sciences Division $11,677,625.00 (12%); Earth and Engineering Sciences Division $2,368,251.00 (2.5%); Fellowships and Awards Division $1,155,120.00 (1%); Social Sciences Division $43,500.00; and the Secretary's Office $158,700.00. Globally, the projects were distributed as follows: Africa (30%); Asia (28%); Latin America (10%); Middle East (8%); Central America (7%); Oceania (0.5%). Fifteen percent (15%) of the projects had a global focus. By Divisions and Programs the projects breakdown as follows: Agriculture, Food and Nutrition Sciences, 310 (88%), with 264 in Crops and Animal Production Systems; Forestry, 21; Forestry -- Integrated Production Systems, 6; Fisheries, 8; Cooperative Programs, 7; Post Production Systems, 3; Environment and

Sustainable Resource Management, 1: Health Sciences, 43 (12%); Tropical and Infectious Diseases, 24; Maternal and Child Health, 12; Health and the Environment, 4; Water Supply and Sanitation, 3: Earth and Engineering Sciences, 7 (2%); Technology for Local Enterprises, 5; Other Fields, 2: Fellowships and Awards, 3; Group Training, 2; Training for Program Development, 1: Social Sciences, 1: Secretary's Office, 1.

9. Science, to quote from the Information Sciences Division (Science and Technology Information Program) Draft for Discussion on "Working to Facilitate Greater Access to Science and Technology Information (STI) in Developing Countries, "can be defined as the pursuit of systematic and ordered knowledge, utilizing a particular methodology called the scientific method. Technology ... can be defined as the set of material tools, knowledge, and skills used to allow the adaptation of means to ends. Theoretically, the difference between science and technology is in terms of their results or products. The product of science is new knowledge; the product of technology is a new process or gadget. However, one of the main features of contemporary science and technology is the increasing interpenetration and cross-fertilization between scientific research and technological development -- science is transformed more and more into technology and industry and technology is becoming more and more science."(2)

10. IDRC Memorandum from Ivan L. Head to Doug Daniels, re.: Biotechnologies, November 11, 1983.

11. IDRC Memorandum from John Hardie to J.H. Hulse, re.: Biotechnology, December 12, 1983.

12. IDRC, "Biotechnology: Opportunities and Constraints," Manuscript Report MR-110e, May 1985.

13. Minutes of the Board of Governors Meeting held on March 27, 28 and 29, 1985, Re.: Biotechnology, April 6, 1985.

14. Correspondence from John Hardie to Calvin R. Cupp, Executive Director of the Canadian Enterprise / Innovation Centre, Queen's University, January 1, 1986.

15. In March 1985 the Centre was invited by the Science and Technology Section of the Department of External Affairs to join the Sub-Committee on Biotechnology, IDRC Memorandum from Paul McConnell to Joe Hulse re.: Interdepartmental Committee on Biotechnology, March 27, 1985.

16. IDRC Memorandum from Hubert Zandra to Joe Hulse re.: Biotechnology in IDRC, April 25, 1985.

17. Memorandum from Geoffrey Hawtin to Jim Mullin, re.: Biotechnology Resources Development Corp (BRDC) Issue of Centre-wide concern, March 15, 1989.

18. This section is based on and contains portions of the 1987-1988 Annual Report of the National Biotechnology Advisory Committee (Industry, Science and Technology Canada) and the "1988 Canadian Biotechnology Industry Sourcebook" (Biotechnology Unit, Ministry of State for Science and Technology, July 1988).

19. Department of Supply and Services Canada, 1981, Task Force on Biotechnology: A Development Plan for Canada (Ottawa: DSS ST31-9/1981E).

20. Medical Research Council, 1977, Guidelines for the

Handling of Recombinant DNA Molecules and Animal Viruses and Cells (Ottawa: MR21-1/1977).

21. Medical Research Council, 1979, Guidelines for the Handling for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells (1st Revisions)(Ottawa:MR21-1/1979), and Medical Research Council, 1980, Guidelines for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells (2nd Revision)(Ottawa: MR21-1/1980).

22. For a review of federal legislation see S. Krimsky, 1984, Regulatory Policies on Biotechnology in Canada. A manuscript report prepared for the Science Council of Canada; and J. Miller, 1986, Canada: Building a regulatory framework, Bio/Technology 4:206-207: D.C. Henley, 1986, Coordinated study on government processes in safety and regulation of modern biotechnology. Draft Report to the Interdepartmental Committee on Biotechnology. Environmental Protection Service, Ottawa: Beak Consultants Limited, 1987, Regulatory Policy Options for Canadian Biotechnology. Draft Report to Ministry of State for Science and Technology, Ottawa.

23. Organization for Economic Cooperation and Development, 1986, Recombinant DNA Safety Considerations (Paris: OECD).

24. Minister of State for Science and Technology, 1988 Canadian Biotechnology Industry Sourcebook, (2-3).

25. This section is based on and contains portions of a Report of the Directorate-General for International Cooperation of the Netherlands, "Biotechnology and Development Cooperation" (Inventory of the biotechnology policy and activities of a number of Donor Countries and Organizations, UN Agencies, Development Banks, and CGIAR), February 1989.

26. The donor agencies and organisations surveyed included: Donor Country Agencies; United Kingdom (ODA), Denmark (DANIDA), Sweden (SAREC), Canada (CIDA), the United States of America (USAID), Federal Republic of Germany (ATSAF), The Netherlands (DGIS): United Nations Agencies; Food and Agricultural Organization (FAO), International Atomic Energy Agency (IAEA), International Fund for Agricultural Development (IFAD), International Labour Organization (ILO), United Nations Centre for Science and Technology of Development (UNCSTD), United Nations Conference for Trade and Development (UNCTAD), United Nations Development Programme (UNPD), United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO), World Food Programme (WFP), World Health Organization (WHO) and World Intellectual Property Organization (WIPO): Development Banks; World Bank (WB), African Development Bank (AfDB), Asian Development Bank (ADB) and Inter-American Bank (IDB): CGIAR Institutes; Centro International de Agricultura Tropical (CIAT), Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), International Board for Plant Genetic Resources (IBPGR), International Centre for Agricultural Research in the Dry Area (ICARDA), International Crops Research Institute for the Semi-Ari Tropics (ICRISAT), International Food Policy Research Institute (IFPRI), International Institute of Tropical Agriculture (IITA), International Livestock Centre for Africa

(ILCA), International Laboratory for Research on Animal Disease (ILRAD), International Rice Research Institute (IRPI), International Service for National Agricultural Research (ISNAR), West Africa Rice Development Association (WARDA).

27. Diretorate-General for International Cooperation (The Netherlands), 1989.

28. The argument presented below is based on the position presented in The Japanese Government, "Human Frontier Science Program," April, 1, 1987.

29. IDRC's mandate is; to contribute to development through research and research supporting activities and to assist in promoting the indigenously determined social and economic advancement of the developing regions of the world, with particular focus on the problem of poverty.

APPENDICES

A. Terms of Reference

B. Biotechnology Related Projects Funded by IDRC

C. National Biotechnology Networks

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE

CENTRE DE RECHERCHES POUR LE DÉVELOPPEMENT INTERNATIONAL

CANADA

APPENDIX A

MEMORANDUM/NOTE DE SERVICE

TO/À: James Mullin

DATE: 8 August 1989

FROM/DE: Marc Van Ameringen

SUBJECT/OBJET: Review of IDRC Activities in the Area of Biotechnology

Based on discussions with Geoffrey Hawtin, I have revised the terms of reference for the proposed consultancy on biotechnology which are outlined below:

1. Review existing Centre files and policy documents related to biotechnology and provide an overview of the main issues that have emerged and discussions that have taken place to date within IDRC on this subject.

2. Using the Centre's information systems, prepare a table of all IDRC projects and DAPs (ongoing and completed) concerning biotechnology.

3. Based on discussions with relevant Divisions, prepare a summary of any current divisional planning processes in the area of biotechnology.

4. Review Canadian Government initiatives in the field of biotechnology and indicate any requirements that the Centre may have to report on our activities in this area.

5. Highlight any discussion and initiatives that have been undertaken by IDRC related to the Canadian academic/research community or private sector.

6. Prepare a summary of donor policy and research initiatives in the area of biotechnology.

7. Prepare a preliminary list and description of the major international institutional initiatives related to biotechnology that address the issues relevant to the developing world.

The consultant will begin his work next week.

APPENDIX B

Biotechnology Related Projects Funded by IDRC

Over the last two decades approximately 9% (351) of all IDRC projects (3997) and about 14% ($97 million) of total IDRC expenditure ($709 million) have been in biotechnology related projects. In the period from 1985 to 1989 the number of biotechnology related projects has declined to 7%, while expenditure on biotechnology related projects fell to 11%.

The Agriculture, Food and Nutrition Sciences Division with $81,241,386.00 (81%) has spent the lion's share of the total expenditure in biotechnology related projects; Health Sciences Division $11,677,625.00 (12%); Earth and Engineering Sciences Division $2,368,251.00 (2.5%); Fellowships and Awards Division $1,155,120.00 (1%); Social Sciences Division $43,500.00; and the Secretary's Office $158,700.00. Globally, the projects were distributed as follows: Africa (30%); Asia (28%); Latin America (10%); Middle East (8%); Central America (7%); Oceania (0.5%). Fifteen percent (15%) of the projects had a global focus.

By Divisions and Programs the projects breakdown as follows: Agriculture, Food and Nutrition Sciences, 310 (88%), with 264 in Crops and Animal Production Systems; Forestry, 21; Forestry -- Integrated Production Systems, 6; Fisheries, 8; Cooperative Programs, 7; Post Production Systems, 3; Environment and Sustainable Resource Management, 1: Health Sciences, 43 (12%); Tropical and Infectious Diseases, 24; Maternal and Child Health, 12; Health and the Environment, 4; Water Supply and Sanitation, 3: Earth and Engineering Sciences, 7 (2%); Technology for Local Enterprises, 5; Other Fields, 2: Fellowships and Awards, 3; Group Training, 2; Training for Program Development, 1: Social Sciences, 1: Secretary's Office, 1.

The key words, taken from the 1985 IDRC Manuscript Report, "Biotechnology: Opportunities and Constraints," used to compile the list of biotechnology related projects funded by IDRC are as follows: nitrogen fixation, pest control, rhizobium, natural pesticides, hopital waste water, piggery waste treatment, biological pest management, genetic, tissue culture, crops and diseases, yellow dwarf, faba pathology, leaf spot, microbial protein, fish parasites, induced spawning, sperm, anticonceptive, bilharzia, mosquitoes, corneal eye, dengue, epidemiology, vaccines, lignocellulolitic fungi, bioconversion lignocellulose, enzyme production, genotyping, dissemination nitrogen, law biotechnology, novel foods, symposium research biotechnology.

Biotechnology Related Projects Funded by IDRC

AGRICULTURE, FOOD AND NUTRITION SCIENCES

Crops and Animal Production Systems

3-P-72-0011 / Sorghum Breeding, Intercropping and Grain Preservation	/ Senegal	/	$957,600
3-P-72-0025 / Intercropping (Tanzania) - Phase I	/ Tanzania	/	$120,570
3-P-72-0051 / Sorghum Improvement (East Africa) - Phase I	/East Africa/		$76,000
3-P-72-0054 / Sorghum, Finger Millet, Pigeon Peas (Uganda) - Phase I	/ Uganda	/	$195,050
3-P-72-0073 / Sorghum (CIMMYT) - Phase I	/ Global	/	$70,170
3-P-72-0095 / Sorghum Improvement (Ethiopia) - Phase I	/ Ethiopia	/	$195,300
3-P-72-0101 / Drought Resistance (Laval) - Phase I	/ Senegal	/	$76,800
Recipient: Universite Laval, Departement de Phytologie			
3-P-73-0010 / Sorghum, Millet, Legumes (ALAD) - Phase I	/Middle East/		$680,300
3-P-73-0012 / Triticale (Chile) - Phase I	/ Chile	/	$91,000
3-P-73-0013 / Grain Legumes (ICRISAT) - Phase I	/ Global	/	$496,000
3-P-73-0050 / Triticale (Kenya)	/ Kenya	/	$87,000
3-P-73-0129 / Drought Tolerance (Saskatchewan) - Phase I	/ Global	/	$672,000
Recipient: University of Saskatchewan. Crop Development Research Centre			
'-73-0136 / Cassava Mites (CIBC) - Phase I	/ Global	/	$13,600
3-P-73-0143 / Sesame (Israel)	/ Israel	/	$92,700
3-P-73-0145 / Rice Research (WARDA) - Phase I	/West Africa/		$410,000
3-P-74-0004 / Triticale (India)	/ India	/	$241,785
3-P-74-0023 / Sorghum Improvement (Ethiopia) - Phase II	/ Ethiopia	/	$560,000
3-P-74-0026 / Winter Triticale (Guelph) - Phase I	/ Global	/	$15,000
Recipient: University of Guelph. Department of Crop Science			
3-P-74-0046 / Cassava (Malaysia)	/ Malaysia	/	$363,100
3-P-74-0054 / Varietal Screening (Philippines) - Phase I	/ Asia	/	$288,000
3-P-74-0107 / Drought Resistance (Laval) - Phase II	/ Senegal	/	$154,900
Recipient: Universite Laval. Departement de Phytologie			
3-P-74-0132 / Sorghum (CIMMYT) - Phase II	/ Global	/	$124,700
3-P-74-0160 / Grain Legumes (Caribbean) - Phase II	/ Caribbean	/	$309,500
3-P-74-0161 / Grain Legumes (ICRISAT) - Phase II	/ Global	/	$998,000
3-P-75-0001 / Root Crops (UWI) - Phase II	/ Caribbean	/	$156,100
3-P-75-0026 / Cassava Mites (CIBC) - Phase II	/ Global	/	$48,000
3-P-75-0032 / Rapeseed (India) - Phase I	/ India	/	$126,000
3-P-75-0037 / Sorghum, Triticale, Oilseeds (Rwanda) - Phase I	/ Rwanda	/	$197,000
3-P-75-0041 / Root Crops (Cameroon/IITA) - Phase I	/ Cameroon	/	$322,200
3-P-75-0072 / Millets (India)	/ India	/	$530,000
3-P-75-0088 / Sorghum (Senegal) - Phase II	/ Senegal	/	$395,730
3-P-75-0094 / Cassava Microbiology (Guelph) - Phase I	/ Global	/	$7,500
3-P-75-0097 / Safflower (India) - Phase I	/ India	/	$100,800
3-P-75-0098 / Sesame (India) - Phase I	/ India	/	$167,000
3-P-75-0110 / Sorghum, Finger Millet, Pigeon Peas (Uganda) - Phase II	/ Uganda	/	$196,390
°-75-0114 / Mustard (India) - Phase I	/ India	/	$270,000
-P-75-0116 / Sorghum/Millets (EAC) - Phase II	/East Africa/		$132,500
3-P-75-0122 / Crop Rotations (Kenya)	/ Kenya	/	$87,400
3-P-75-0123 / Cassava Cooperative Research (Asia)	/ Asia	/	$440,000

-75-0131	Pigeon Peas (Kenya)	Kenya	$103,000
3-P-76-0052	Triticale Outreach (Ethiopia) - Phase II	Ethiopia	$176,200
3-P-76-0078	Quinoa (Bolivia) - Phase I	Bolivia	$315,500
3-P-76-0105	Cassava (Zanzibar) - Phase I	Tanzania	$73,176
3-P-76-0134	Cold-Tolerant Sorghum (ICRISAT) - Phase I	Global	$198,600
3-P-76-0148	Winter Triticale (Guelph) - Phase II	Global	$93,800
3-P-76-0149	Triticale (Manitoba)	Global	$121,800
	Recipient: University of Manitoba. Faculty of Agriculture		
3-P-76-0160	Cassava Mealy Bug (CIBC) - Phase I	Brazil	$56,300
3-P-76-0191	Grain Legumes (Caribbean) - Phase III	Caribbean	$273,500
3-P-77-0041	Striga (Sudan) - Phase I	Sudan	$251,200
3-P-77-0048	Grain Legumes (Bangladesh) - Phase I	Bangladesh	$220,000
3-P-77-0049	Root Crops (Sri Lanka) - Phase I	Sri Lanka	$173,000
3-P-77-0060	Food Legume Improvement (Sudan) - Phase I	Sudan	$210,200
3-P-77-0073	Food Legume Improvement (Egypt) - Phase I	Egypt	$243,800
3-P-77-0081	Winter Triticale (Guelph) - Phase III	Burundi	$210,200
3-P-77-0083	Beans and Maize Improvement (Burundi) - Phase I	Burundi	$251,800
3-P-77-0092	Food Legumes (Niger)	Niger	$153,000
3-P-77-0101	Grain Legumes (ICARDA) - Phase I	Middle East	$942,850
3-P-77-0102	Food Legumes (Sierra Leone) - Phase I	Sierra Leone	$126,000
3-P-77-0125	Pasture Legumes (ICARDA)	Middle East	$583,300
3-P-77-0159	Cowpea Storage (Upper Volta) - Phase I	Burkina Faso	$110,000
3-P-78-0032	Pasture Legumes (Panama)	Panama	$154,800
3-P-78-0035	Amazonian Production Systems (Peru) - Phase I	Peru	$298,700
3-P-78-0036	Pasture Development (Chile) - Phase I	Chile	$326,800
-78-0039	Plantains (Cameroon) - Phase I	Cameroon	$162,000
3-P-78-0040	Food Legumes (Mali) - Phase I	Mali	$212,000
3-P-78-0041	Orobanche Control (ICARDA) - Phase II	Middle East	$106,000
3-P-78-0042	Barley Improvement (Turkey)	Turkey	$219,100
3-P-78-0043	Grain Legumes (Algeria) - Phase II	Algeria	$197,300
3-P-78-0044	Oilseeds (Egypt) - Phase I	Egypt	$223,000
3-P-78-0045	Varietal Screening (Philippines) - Phase II	Asia	$230,900
3-P-78-0046	Drought Resistant Crops (Catie) - Phase I	Central America	$180,000
3-P-78-0047	Rice Research (WARDA) - Phase II	Senegal	$682,145
3-P-78-0048	Food Legumes (Turkey) - Phase I	Turkey	$255,500
3-P-78-0092	Cold-Tolerant Sorghum (ICRISAT) - Phase II	Global	$122,500
3-P-79-0016	Sorghum Improvement (Ethiopia) - Phase III	Ethiopia	$498,500
3-P-79-0017	Groundnut Improvement (Mozambique) - Phase I	Mozambique	$271,300
3-P-79-0022	Wild Cassava (Brazil)	Brazil	$54,500
3-P-79-0027	Food Legume Drought Tolerance (IITA/Niger)	West Africa	$63,000
3-P-79-0038	Food Legumes (Upper Volta/IITA) - Phase II	Burkina Faso	$331,000
3-P-79-0040	Root Crops (Congo Brazzaville)	Congo	$105,000
3-P-79-0052	Triticale (Chile) - Phase III	Chile	$197,920
3-P-79-0063	Pigeon Peas (Kenya) - Phase II	Kenya	$134,700
3-P-79-0064	Drought Tolerance (Saskatchewan) - Phase II	Global	$273,400
	Recipient: University of Saskatchewan		
3-P-79-0065	Cassava Mites (Trinidad) (CIBC) - Phase III	Global	$132,300
3-P-79-0087	Root Crops (Cameroon/IITA) - Phase II	Cameroon	$386,362
3-P-79-0090	Food Legumes (Pakistan)	Pakistan	$376,100
3-P-79-0094	Sorghum (Senegal) - Phase III	Senegal	$132,000
-79-0101	Legumes Under Bananas (UPEB)	Panama	$76,100
-79-0104	Oilseeds (Sri Lanka) - Phase I	Sri Lanka	$246,200
3-P-79-0134	Grain Legumes (Bangladesh) - Phase II	Bangladesh	$400,800
3-P-79-0137	Lignocellulolytic Fungi (Thailand) - Phase I	Thailand	$30,473

-79-0142	Pulses and Groundnuts (Tanzania) - Phase I	Tanzania	$321,205
3-P-79-0144	Grain Legumes (ICARDA) - Phase II	Middle East	$1,050,000
3-P-79-0172	Food Legume Insect Control (Upper Volta)	Burkina Faso	$144,300
3-P-80-0009	Faba Bean Diseases (Manitoba) - Phase I	Global	$114,300
	Recipient: University of Manitoba. Department of Plant Science		
3-P-80-0056	Sorghum/Millets (Uganda) - Phase III	Uganda	$307,300
3-P-80-0082	Food Grain Improvement (Sri Lanka) - Phase II	Sri Lanka	$279,900
3-P-80-0102	Oilseeds (Sudan) - Phase I	Sudan	$322,800
3-P-80-0103	Sorghum Improvement (Somalia) - Phase I	Somalia	$276,900
3-P-80-0115	Quinoa (Bolivia) - Phase II	Bolivia	$352,600
3-P-80-0116	Cassava Mealy Bug (CIBC) - Phase II	Latin America	$195,900
3-P-80-0118	Food Legume Improvement (Egypt) - Phase II	Egypt	$311,200
3-P-80-0131	Highland Oil Crops Improvement (Ethiopia)	Ethiopia	$375,300
3-P-80-0161	Food Legumes (IRRI/UPLB)	Asia	$550,300
3-P-80-0189	Bananas (Philippines) - Phase I	Philippines	$352,600
3-P-81-0001	Cassava (Zanzibar) - Phase II	Tanzania	$160,400
3-P-81-0002	Food Legumes (IITA) - Phase III	West Africa	$449,500
3-P-81-0006	Food Legumes (Sierra Leone) - Phase II	Sierra Leone	$173,000
3-P-81-0025	Cereals (Rwanda) - Phase II	Rwanda	$290,000
3-P-81-0057	Millet and Sorghum (Zimbabwe)	Zimbabwe	$337,700
3-P-81-0079	Sweet Potatoes (Philippines) - Phase I	Philippines	$76,200
3-P-81-0089	Peas and Maize Improvement (Burundi) - Phase II	Burundi	$350,640
3-P-81-0101	Grain Legumes (Icarda) - Phase III	Global	$950,000
3-P-81-0113	Striga (Upper Volta) - Phase II	West Africa	$500,000
3-P-81-0114	Food Legumes (Burkina Faso) - Phase III	Burkina Faso	$182,700
-81-0115	Pasture Development (Chile) - Phase II	Chile	$325,000
3-P-81-0117	Oilseeds (Egypt) - Phase II	Egypt	$317,400
3-P-81-0130	Bamboo (China) - Phase I	China	$265,500
3-P-81-0133	Tropical Pastures Network (Colombia) - Phase I	Latin America	$354,400
3-P-81-0174	Plantain Cropping Systems (Catie) - Phase I	Central America	$197,000
3-P-81-0175	Root Crops (Liberia) - Phase I	Liberia	$192,200
3-P-81-0183	Rice Research (Warda) - Phase III	West Africa	$372,300
3-P-82-0012	Vegetable Seed (Thailand) - Phase I	Thailand	$234,100
3-P-82-0013	Intercropping (Swaziland) - Phase II	Swaziland	$164,800
3-P-82-0014	Groundnut Improvement (Thailand) - Phase I	Thailand	$356,900
3-P-82-0015	Erythrina (Catie) - Phase I	Costa Rica	$389,900
3-P-82-0059	Mustard (India) - Phase II	India	$154,400
3-P-82-0060	Rapeseed (India) - Phase II	India	$153,600
3-P-82-0061	Safflower (India) - Phase II	India	$145,800
3-P-82-0062	Sesame (India) - Phase II	India	$149,800
3-P-82-0073	Root Crops (Congo-Brazzaville) - Phase II	Congo	$139,000
3-P-82-0084	Plantain / Banana Improvement (Jamaica)	Jamaica	$93,500
3-P-82-0088	Tropical Pasture Evaluation (Ecuador) - Phase I	Ecuador	$228,100
3-P-82-0093	Groundnut Improvement (Mozambique) - Phase II	Mozambique	$745,100
3-P-82-0094	Striga (Sudan) - Phase II	Sudan	$211,600
3-P-82-0096	Lowland Oil Crops Improvement (Ethiopia)	Ethiopia	$434,600
3-P-82-0098	Cassava and Sweet Potato (Rwanda) - Phase I	Rwanda	$471,732
3-P-82-0137	Lignocellulolytic Fungi (Thailand) - Phase II	Thailand	$139,800
3-P-82-0139	Pigeon Peas (Kenya) - Phase III	Kenya	$230,000
3-P-82-0144	Rapeseed (China)	China	$602,900
P-82-0154	Biological Pest Management (India) - Phase I	India	$128,100
P-82-0179	Tropical Pasture Evaluation (Colombia)	Colombia	$127,000
3-P-82-0180	Tropical Pasture Evaluation (Panama)	Panama	$78,600
3-P-82-0186	Food Legumes (Indonesia) - Phase I	Indonesia	$234,500

-82-0187	Millets (India) - Phase II	India	$435,900
3-P-82-0188	Vegetables (China)	China	$480,410
3-P-82-0190	Fish Parasites (Malaysia) - Phase II	Malaysia	$170,500
3-P-82-0198	Fish Parasites (Indonesia) - Phase II	Indonesia	$382,800
3-P-82-0256	Food Legumes (IITA) - Phase IV	West Africa	$618,516
3-P-83-0008	Sorghum Improvement (Somalia) - Phase II	Somalia	$479,500
3-P-83-0022	Plantains (Cameroon) - Phase II	Cameroon	$174,900
3-P-83-0025	Food Legumes (Mali) - Phase II	Mali	$198,920
3-P-83-0035	Sweet Potatoes (Philippines) - Phase II	Philippines	$439,900
3-P-83-0079	Potatoes from Seed (Egypt)	Egypt	$204,400
3-P-83-0111	Dairy Production Systems (Sudan)	Sudan	$255,600
3-P-83-0122	Food Legume Improvement (Sudan) - Phase II	Sudan	$265,200
3-P-83-0123	Food Legumes North Africa (ICARDA)	North Africa	$599,300
3-P-83-0128	Pracipa Network (CIP) - Phase I	Andean Region	$504,000
3-P-83-0132	Root Crops (Cameroon/IITA) - Phase III	Cameroon	$455,700
3-P-83-0133	Root Crops (Uganda)	Uganda	$330,400
3-P-83-0143	Cassava Mites (Eastern Africa) CIBC) - Phase IV	East Africa	$140,100
3-P-83-0175	Oilseeds Network (Ethiopia) - Phase II	Global	$515,800
3-P-83-0182	Striga (Upper Volta) III	Burkina Faso	$300,000
3-P-83-0199	Root Crops (Sri Lanka) - Phase II	Sri Lanka	$287,400
3-P-83-0211	Lentil/Chickpea Improvement Mechanization - Phase II	Jordan	$350,690
3-P-83-0215	Peas and Maize Improvement (Burundi) - Phase III	Burundi	$540,400
3-P-83-0217	Tropical Pastures Network (Colombia) - Phase II	Latin America	$737,100
3-P-84-0039	Highland Oilcrops Improvement (Ethiopia) - Phase II	Ethiopia	$337,500
3-P-84-0113	Coffee Berry Borer (CIBC/Mexico)	Mexico	$401,400
-84-0136	Groundnuts (Malawi) - Phase II	Southern Africa	$752,400
3-P-84-0137	Oilseeds (Sudan) - Phase II	Sudan	$309,740
3-P-84-0149	Improved Crops for Small Farmers (Chile) - Phase I	Chile	$307,200
3-P-84-0219	Sorghum and Millets (Uganda) - Phase IV	Uganda	$382,500
3-P-84-1020	Soy Rhizobia (Alberta/Thailand)	Thailand	$483,000
	Recipient: Agriculture Canada, Soil Science Section (Lethbridge)		
3-P-84-1035	Faba Bean Pathology (Manitoba / ICARDA) - Phase III	Global	$648,500
	Recipient: University of Manitoba, Department of Plant Science		
3-P-84-1042	Lentil Haploids (Manitoba / ICARDA)	Global	$146,600
	Recipient: University of Manitoba		
3-P-84-1053	Oilseed Anther Culture (Agriculture Canada/Network)	Global	$119,100
	Recipient: Agriculture Canada, Research Station		
3-P-84-1055	Faba Bean Pollination (Manitoba /ICARDA)	Global	$99,000
	Recipient: University of Manitoba, Faculty of Agriculture		
3-P-84-1058	Root Crop (Montreal/Ivory Coast)	Cote d'Ivoire	$128,002
	Recipient: Universite de Montreal		
3-P-85-0010	Vegetable Seed Production (Thailand) - Phase II	Thailand	$245,300
3-P-85-0012	Quinoa (Bolivia) - Phase III	Bolivia	$339,000
3-P-85-0013	Plantain/Banana Improvement (Honduras)	Honduras	$190,000
3-P-85-0015	Root and Plantain Cropping Systems (CATIE)-Phase II	Central America	$351,900
3-P-85-0018	Grain Legumes (Bangladesh) - Phase III	Bangladesh	$270,400
3-P-85-0019	Pulses and Groundnuts (Tanzania) - Phase II	Tanzania	$286,900
3-P-85-0022	Millets (Bangladesh) - Phase II	Bangladesh	$273,800
3-P-85-0027	Food Legumes (Pakistan) - Phase II	Pakistan	$335,600
3-P-85-0050	Food Legumes (IITA) - Phase V	West Africa	$603,400
P-85-0092	Groundnut Improvement (Thailand) - Phase II	Thailand	$169,900
P-85-0129	Food Legumes (IRRI/UPLB) - Phase II	Asia	$321,900
3-P-85-0134	Grain Legumes (Nepal)	Nepal	$287,440
3-P-85-0138	Quinoa Production (Ecuador) - Phase II	Ecuador	$243,900

-85-0167	Pasture Network for Eastern and Southern Africa (PANESA)	Africa	$400,000
3-P-85-0191	Food Legumes (Turkey) - Phase II	Turkey	$198,200
3-P-85-0192	Roots and Tubers (Zanzibar) - Phase III	Tanzania	$175,000
3-P-85-0222	Cassava and Sweet Potato (Rwanda) - Phase II	Rwanda	$245,000
3-P-85-0339	Tissue Culture (Colombia)	Colombia	$50,300
3-P-85-1047	Biological Control (Guelph/China)	Global	$449,700
	Recipient: University of Guelph. Department of Environmental Biology		
3-P-85-1012	Yellow Dwarf Virus (Laval) - Phase II	Global	$147,402
	Recipient: Universite Laval, Departement de phytologie		
3-P-85-1050	Microbial Control (Agriculture Canada/Egypt) - Phase I	Global	$388,400
	Recipient: Agriculture Canada, Research Station		
3-P-86-0012	Cassava Mites (Eastern Africa/CIBC) - Phase V	Africa	$359,000
3-P-86-0089	Food Grain Improvement (Sri Lanka) - Phase III	Sri Lanka	$213,700
3-P-86-0092	Oil-Crops for Reclaimed Lands (Egypt) - Phase III	Egypt	$328,100
3-P-86-0099	Soybeans (Pakistan)	Pakistan	$316,000
3-P-86-0105	Bananas/Plantains Somaclonal Mutation (CATIE)	Global	$175,500
3-P-86-0115	Tropical Pasture Evaluation (Mexico)	Mexico	$176,200
3-P-86-0124	Andean Crops/Livestock Systems (Peru) - Phase III	Peru	$178,500
3-P-86-0191	Trifolium Rhizobia (UBC/ILCA)	Africa South	$156,800
	Recipient: University of British Columbia. Department of Plant Science		
3-P-86-0200	Bananas (Philippines) - Phase II	Philippines	$312,800
3-P-86-0212	Maize and Peas (Burundi) - Phase IV	Burundi	$581,500
3-P-86-0224	Pigeon Peas (Kenya) - Phase IV	Kenya	$305,000
3-P-86-0233	Biological Pest Management (India) - Phase II	India	$186,000
3-P-86-0241	PRACIPA Network (CIP) - Phase II	Andean Region	$517,000
-86-0284	Sorghum Improvement (Somalia) - Phase III	Somalia	$369,300
3-P-86-1016	Rhizobial Carrier Systems (Manitoba/ICARDA) - Phase II	Middle East	$335,200
	Recipient: University of Manitoba, Department of Plant Science		
3-P-86-1020	Yellow Dwarf Virus (Laval/ICARDA/Chile) - Phase III	Global	$335,000
	Recipient: Laval University, Department of Phytology		
3-P-86-1049	Aphid Biocontrol (ABN/China)	China	$56,200
	Recipient: Applied Bio-Nomics Ltd. (ABN) (Sidney, B.C.)		
3-P-86-1046	Rapeseed (Agriculture Canada/China) - Phase II	China	$554,300
	Recipient: Agriculture Canada, Research Branch		
3-P-87-1009	Leaf Spot (Alberta/Costa Rica) - Phase II	Costa Rica	$328,700
	Recipient: University of Alberta, Department of Chemistry		
3-P-87-1010	Weevil Resistance (Ottawa/CIMMYT/Mexico/Zimbabwe) Phase II	Global	$278,400
	Recipient: University of Ottawa, Centre for Graduate Studies and Research in Biology		
3-P-87-1014	Bacillus Thuringiensis Elisa (UWO)	Global	$28,600
	Recipient: University of Western Ontario, Faculty of Engineering Science		
3-P-87-1022	Botanical Pesticides (Ottawa/Philippines)	Philippines	$301,800
	Recipient: University of Ottawa, Faculty of Science		
3-P-87-0133	Integrated Pest Management (Philippines)	Philippines	$108,100
3-P-87-0007	Plantain Production Improvement (Colombia)	Colombia	$246,600
3-P-87-0021	Hill Crops (Nepal)	Nepal	$485,000
3-P-87-0025	Oilseeds Network (Ethiopia) - Phase III	Global	$557,811
3-P-87-0026	Peach Palm and Aroids (Costa Rica)	Costa Rica	$336,900
3-P-87-0038	Groundnut Improvement (Mozambique) - Phase III	Mozambique	$501,600
3-P-87-0039	Oilseeds (Sri Lanka) - Phase II	Sri Lanka	$202,400
3-P-87-0070	Sesame Research (India)	India	$96,900
-87-0132	Food Legumes (Mali) - Phase III	Mali	$259,800
-87-0201	Banana and Plantain Network (INIBAP) - Phase IV	Global	$150,000
3-P-87-0233	Tropical Pastures Network (CIAT) - Phase III	Latin America	$671,600
3-P-87-0246	Vegetables (China) - Phase II	China	$454,600

-87-0255	Oil Crops (Ethiopia)	Ethiopia	$465,900
3-P-87-0261	Triticale (Syria)	Syria	$276,300
3-P-87-1043	Leucaena Psyllid Bio-Control (AEC/ASIA/CIBC)	SE Asia	$256,500
	Recipient: Alberta Environmental Centre (AEC)		
3-P-88-0020	Vegetable Seed Production (Thailand) - Phase III	Thailand	$347,100
3-P-88-0021	Sesame for Rice-based Farming Systems (Philippines)	Philippines	$68,500
3-P-88-0024	Food Legumes (Indonesia) - Phase II	Indonesia	$361,700
3-P-88-0063	Highland Sweet Potatoes (Philippines)	Philippines	$73,850
3-P-88-0081	Eucalyptus Improvement (Chile)	Chile	$25,380
3-P-88-0114	Root Crops (Liberia) - Phase II	Liberia	$306,700
3-P-88-0117	Banana Cropping Systems (Uganda)	Uganda	$250,700
3-P-88-0146	Root Crops (Malawi)	Malawi	$223,000
3-P-88-1004	Rapeseed/Mustard (Agriculture Canada/India)	India	$538,000
	Recipient: Agriculture Canada, Agriculture Canada Research Station (Saskatoon)		
3-P-88-1043	Microbial Control (Agriculture Canada/Egypt) - Phase II	Global	$496,900
	Recipient: Agriculture Canada, Research Branch (Ottawa)		
3-P-89-1012	Botanical Pesticides (Ottawa/Thailand/UBC)	Thailand	$419,600
	Recipient: University of Ottawa, Faculty of Science		

Forestry

3-P-75-0048	Casuarina (Egypt) - Phase I	Middle East	$134,400
3-P-77-0008	Pine Beetle (Guatemala)	Guatemala	$31,900
3-P-79-0026	Bamboo (Bangladesh)	Bangladesh	$183,700
3-P-82-0069	Tree Seed Improvement (Ecuador)	Ecuador	$174,900
-82-0121	Paulownia (China)	China	$356,000
-P-83-0059	Nitrogen-Fixing Trees (Sierra Leone)	Sierra Leone	$109,200
3-P-83-0106	Cowpea Storage (Sierra Leone) - Phase II	Sierra Leone	$113,650
3-P-83-0288	Rattan (Indonesia) - Phase I	Indonesia	$208,970
3-P-83-0296	Bamboo (Bangladesh) - Phase II	Bangladesh	$144,465
3-P-84-0046	Tissue Culture / Rattan (Malaysia) - Phase I	Malaysia	$120,690
3-P-84-0088	Root Symbiosis (Sierra Leone)	Sierra Leone	$49,650
3-P-85-0009	Tree Seed Improvement (Colombia)	Colombia	$221,800
3-P-85-0105	Bamboo Tissue Culture (Philippines)	Philippines	$74,700
3-P-85-0112	Forest Tissue Culture (Colombia)	Colombia	$123,700
3-P-85-0186	Erythrina (CATIE) - Phase II	Central America	$602,570
3-P-85-0263	Multi-purpose Trees (India)	India	$245,000
3-P-85-0264	Prosopis (Brazil)	Brazil	$241,900
3-P-86-0148	Acacia Root Symbiosis (Tunisia) - Phase I	Tunisia	$81,500
3-P-87-0236	Tissue Culture (India)	India	$157,600
3-P-88-0003	Chachafruto (Colombia) - Phase I	Colombia	$19,040
3-P-89-1016	Acacia Root Symbiosis (Laval/Tunisia) - Phase II	Tunisia	$222,550
	Recipient: Universite Laval, Cite universitaire. Ste-Foy (Quebec)		

Forestry -- Integrated Production Systems

3-P-86-0164	Paulownia (China) - Phase II	China	$370,000
3-P-87-0015	Acacia Albida (Burkina Faso)	Burkina Faso	$110,400
3-P-88-0126	Rattan (Malaysia) - Phase II	Malaysia	$246,000
3-P-88-0162	Prosopis (Argentina)	Argentina	$125,800
-P-88-0293	Forest Tree Culture (Egypt)	Egypt	$521,300
P-89-0052	MPT Tissue Culture (ILCA)	Africa	$82,450

Fisheries

3-P-73-0147 / Fish Parasites (Indonesia) - Phase I / Indonesia / $235,300
3-P-79-0069 / Fish Parasites (Philippines) /Philippines/ $24,800
3-P-79-0085 / Fish Parasites (Malaysia) - Phase I / Malaysia / $18,400
3-P-82-1015 / Carp Genetics (Dalhousie/Indonesia) - Phase II / Indonesia / $383,700
Recipient: Dalhousie University, Research Services
3-P-83-1011 / Induced spawning (Alberta/China) / China / $375,381
Recipient: University of Alberta, Department of Zoology
3-P-85-1051 / Fish Genetics Network (Dalhousie/Asia) / Asia / $640,278
Recipient: Dalhousie University
3-P-86-0030 / Fish Genetics (Thailand) - Phase II / Thailand / $375,300
3-P-87-1028 / Induced Spawning (Alberta/China/Guelph) - Phase II / China / $287,500
Recipient: University of Alberta, Department of Zoology

Cooperative Programs

3-P-81-1001 / Microbial Protein (Guelph) / Global / $133,850
Recipient: University of Guelph, Department of Microbiology
3-P-81-1005 / Yellow dwarf virus (Laval) - Phase I / Global / $162,000
Recipient: Universite Laval, Departement de Phytologie
3-P-82-1001 / Faba Bean Pathology (Manitoba) - Phase II / Global / $193,286
Recipient: University of Manitoba, Department of Plant Science
3-P-82-1002 / Rhizobial Carrier Systems (Manitoba) /Middle East/ $170,300
Recipient: University of Manitoba, Department of Plant Science
3-P-83-1031 / Genotyping (Manitoba / CIAT) / Global / $337,500
cipient: University of Manitoba, Department of Plant Science
3-P-83-1032 / Tissue Culture (Calgary / Costa Rica) / Costa Rica/ $202,500
Recipient: University of Calgary, Department of Biology
3-P-84-1006 / Leaf Spot (Alberta/Costa Rica) / Costa Rica/ $382,800
Recipient: University of Alberta, Department of Chemistry

Post Production Systems

3-P-73-0009 / Grain Storage (Ghana) / Ghana / $22,700
3-P-80-0125 / Faba Beans (Egypt) - Phase II / Egypt / $160,200
3-P-83-1004 / Natural Pesticides (Carleton University) /Burkina Faso/ $18,900
Recipient: Carleton University, Department of Biology

Environment and Sustainable Resource Management

3-P-89-0071 / Agroforestry Seed Clearing House (Philippines) /Philippines/ $16,290

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HEALTH SCIENCES

Tropical and Infectious Diseases

3 76-0184 / Bilharzia (Egypt) - Phase I / Egypt / $51,549
3-P-78-0069 / Dengue Hemorrhagic Fever Surveillance (Indonesia) / Indonesia / $137,500
3-P-79-0123 / Dengue Hemorrhagic Fever Sulawesi (Indonesia) / Indonesia / $29,650

3-P-80-0194	Bilharzia (Egypt) - Phase II	Egypt	$66,255
3-P-81-1002	Bio-control of Mosquitos (South Pacific) - Phase I	Oceania	$33,500
	Recipient: Memorial University of Newfoundland (MUN)		
3-P-82-0107	Dengue Hemorrhagic Fever (Cuba)	Cuba	$163,100
3-P-82-0223	Bilharzia (Egypt) - Phase III	Egypt	$246,086
3-P-82-0225	Yellow Fever (Latin America) - Phase I	Latin America	$312,610
3-P-82-1008	Bio-control of Mosquitos (South Pacific) - Phase II	Oceania	$38,400
	Recipient: Memorial University of Newfoundland (MUN)		
3-P-83-0087	Conference on Dengue/Dengue Hemorrhagic Fever (DF/DHF)	Global	$45,030
3-P-83-0140	Tuberculosis (Korea)	Korea	$136,050
3-P-83-0213	Hepatitis B (Malaysia)	Malaysia	$75,120
3-P-83-1029	Corneal Eye Infections (Nepal)	Nepal	$143,140
	Recipient: University of Calgary		
3-P-84-0033	Epidemiology of Dengue (Malaysia) - Phase I	Malaysia	$143,675
3-P-84-0054	B. C. G. Vaccination (Kenya)	Kenya	$113,434
3-P-84-0079	Vaccine Trial Centre (Thailand)	Thailand	$191,435
3-P-85-0042	Yellow Fever (Latin America) - Phase II	Latin America	$215,455
3-P-85-0188	Dengue (Honduras)	Honduras	$85,620
3-P-86-0010	Dengue Haemorrhagic Fever (Cuba) - Phase II	Cuba	$114,290
3-P-86-0131	Determinants of Dengue (Mexico)	Mexico	$143,900
3-P-87-0122	Diagnosis of Dengue (Malaysia)	Malaysia	$135,870
3-P-87-0198	Epidemiology of Dengue (Malaysia) - Phase II	Malaysia	$100,550
3-P-87-0204	Bilharzia (Egypt) - Phase IV	Egypt	$356,080
3-P-87-0271	Yellow Fever Vaccine (Nigeria)	Nigeria	$1,155,120

Maternal and Child Health

3-P-75-0106	Anticonceptive Technology (ICCR II/India) - Phase I	India	$3,000,000
3-P-78-0021	Sperm Inhibition (Chile) - Phase I	Global	$128,005
	Recipient: Queen's University. Department of Biochemistry		
3-P-79-0132	Initiation of Sperm Motility (Thailand) - Phase I	Thailand	$61,600
3-P-79-0150	Antioconceptive Technology - ICCR (India) - Phase II	Global	$550,000
3-P-80-0069	Time-Temperature Indicators (Global) - Phase I	Global	$75,000
3-P-80-0090	Sperm Inhibition (Chile) - Phase II	Global	$209,500
	Recipient: Queen's University. Department of Biochemistry		
3-P-81-0023	Time-Temperature Indicators (Global) - Phase II	Global	$163,100
	Recipient: Institut Armand-Frappier (IAF) Quebec		
3-P-82-0008	Initiation of Sperm Motility (Thailand) - Phase II	Global	$66,600
3-P-82-0155	Anticonceptive Technology - ICCR (India) - Phase III	Global	$711,320
3-P-83-1006	Sperm Inhibition (Chile) - Phase III	Global	$466,420
	Recipient: Queen's University. Department of Biochemistry		
3-P-85-0261	Anticonceptive Technology - NII/ICCR (India) - Phase IV	Global	$1,058,000
3-P-85-0302	Inhibition of Sperm Motility (Thailand) - Phase III	Global	$91,420
3-P-86-1018	Sperm Inhibition (Chile/Canada) - Phase IV	Global	$130,137
	Recipient: Queen's University. Department of Biochemistry		

Health and the Environment

3-P-88-0214	Diagnosis of Dengue (Brazil)	Brazil	$98,030
3-P-88-0246	Corneal Eye Infections (Nepal) - Phase II	Nepal	$270,340
P-88-0381	Measles Immunization (Philippines)	Philippines	$130,620
P-89-0041	Anticonceptive Technology - NII (India) - Phase V	India	$698,150

Water Supply and Sanitation

3-P-76-0141 / Piggery Waste Treatment (Singapore) - Phase I / Singapore / $302,984
3-P-79-0071 / Piggery Waste Treatment (Singapore) - Phase II / Singapore / $302,500
3-P-83-0156 / Piggery Waste Treatment (Malaysia) / Malaysia / $85,600

EARTH AND ENGINEERING SCIENCES

Technology for Local Enterprises

3-P-85-1016 / Biogas Refrigerator (China) / China / $269,385
Recipient: Canadian Gas Research Institute
3-P-85-1033 / Technology Adoption SMEs (Malaysia) - Phase II / Malaysia / $262,000
Recipient: Saskatchewan Research Council / University of Saskatchewan, College of Commerce
3-P-87-1024 / Sugar Cane Waste Utilization (Cuba) / Cuba / $441,000
Recipient: University of British Columbia, Department of Chemistry
3-P-87-1034 / Technology Adoption SMEs (Thailand) / Thailand / $214,200
Recipient: University of Saskatchewan, College of Commerce / Saskatchewan Research Council
3-P-87-1051 / Partial Carbonization of Peat (Burundi) / Burundi / $145,365
Recipient: Societe d'ingenierie Cartier Limitee (Montreal)
3-P-87-1052 / Technology Adoption by SMEs in Singapore / Singapore / $216,250
Recipient: University of Saskatchewan, College of Commerce / Saskatchewan Research Council

Other Fields

3-P-84-1048 / Technology Adoption SMEs (Malaysia) / Malaysia / $129,881
Recipient: Saskatchewan Research Council / University of Saskatchewan, College of Commerce
3-P-85-1038 / Industrial Waste Treatment Biogas (India) / India / $690,170
Recipient: National Research Council of Canada (NRC) / Carleton University

FELLOWSHIPS AND AWARDS

Group Training

3-P-85-0219 / Training Course: Insect Pest Management - Phase I / Africa / $58,200
3-P-85-0237 / Training: Varietal Testing & Improvement of Dryland Legume/ Asia / $111,345

Training for Program Development

3-P-87-0064 / Training Course: Insect Pest Management - Phase II / Africa / $67,920

APPENDIX C

NATIONAL BIOTECHNOLOGY STRATEGY/CONTACTS

BIOTECHNOLOGY SECRETARIAT

Technology Policy Branch, ISTC
240 Sparks St., 8th Floor West, Ottawa, Canada, K1A 1A1

National Biotechnology Advisory Committee
Interdepartmental Committee on Biotechnology
Contact: M. Louise McArthur - 613/993-6045

IRAP - BIOTECHNOLOGY FUNDING PROGRAM

Dr. Denys Cooper - 613/993-5539
General Manager, IRAP & Laboratory Network
National Research Council of Canada

THE NATIONAL BIOTECHNOLOGY NETWORKS

NAME	AREA	DEPARTMENT(S)	COORDINATOR(S)	TELEPHONE
BIONIF	Nitrogen Fixation	Agriculture Canada	Dr. L.R. Barran	613/995-3700
			Dr. R. Watson	613/995-3700
BIOCROP	Plant Strain Development		Dr. W. Keller	613/995-3700
BIONET	Human and Animal Health Care Products	National Health and Welfare	Dr. Keith Bailey	613/957-1058
		Agriculture	Dr. J. Pantekoek	613/995-5433
BIOMINET	Mineral Leaching and Metal Recovery	Energy, Mines and Resources	Dr. R.G.L. McCready	613/992-1596
BIOFOR	Forestry and Forest Products	National Research Council	Mr. W. Campbell	613/993-7659
BIOQUAL	Waste Treatment	National Research Council	Dr. P. Matteau	613/993-7630
		Environment Canada	Mr. S. Hart	613/994-2103
AQUATECH	Fisheries/ Marine Aqua-culture	Fisheries and Oceans	Ms. I. Price	613/990-0275

SOCIAL SCIENCES

3-P-82-0120 / Dissemination of Biological Nitrogen Fixation Technology/ Kenya / $43,500

SECRETARY'S OFFICE

3-P-82-0043 / Law and Biotechnology / Global / $158,700